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NOTES ON FEMALE PARAIULIDS

(Myriapods), with Description of a New Species.

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The material submitted to examination is composed of two species of *Paeromopus* and of six representatives of the genus *Paraiulus*. Of the two *Paeromopus*, one is the well known *P. lysiopetalinus* Karsch, while the other, being new to science, will be spoken of as *Paeromopus Chamberlini* and will be described hereafter. The *Paraiulus* species are *P. tiganus* Chamb., *P. pennsylvanicus* (Brandt) Wood, *P. immaculatus* Wood, *P. impressus* Say, *P. venustus* Wood, and the species recorded by the author (1895) as *P. ellipticus* Bollman. Most of the *Paraiulus* specimens have been obtained through the kindness of Ralph V. Chamberlin, of the Museum of Comparative Zoology, in Cambridge, to whom the writer wishes to express herewith his indebtedness.

It may safely be stated that, on the whole, the study of female Diplopods, and particularly of their sexual organs, has been completely neglected, attention having been almost exclusively devoted to the male copulatory apparatus. H. C. Wood (1865, Trans. Amer. Phil. Soc., XIII) is probably the first author having made use of the vulvæ in identifying Paraiulid species.

The distrust in which the females have been held is probably due to the fact that the male structures happened to be so multifarious and of such constancy as to afford the easiest

and most reliable means of identification of the species, while on the other hand the vulvæ appeared less manifold and did not supply equally favorable criteria. Another reason lies in this, that the vulvæ have long remained a mystery.

Since 1909 (Sitzb. Ges. naturf. Freunde Berlin, 1909, No. 4), Verhoeff claimed to have settled the matter by holding that the vulvæ—as well as the penis— had to be identified with pairs of limbs. These were supposed to be the posterior limbs of the third segment, which the author admitted to be

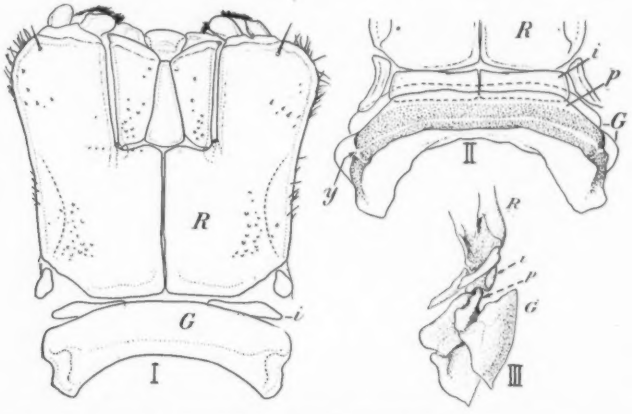

Fig. I. *Paeromopus lysiopetalinus;* gnathochilarium, ventral aspect.
Fig. II. *Paraiulus tiganus.* Base of gnathochilarium of adult female, dorsal aspect. The postmentum, *p*, is fastened to the gula, *G*, along the line left blank, *y*.
Fig. III. *Paraiulus venustus.* Base of gnathochilarium of adult female seen obliquely from the side.

double, as the abdominal segments. It was in fact but a mere personal view, supported by no convincing reasons, and has been contradicted by Brolemann & Lichtenstein (1919, Arch. Zool. exper. gen., LVIII, fasc. 4, mars, 1919), who admit that the so-called vulvæ are not the equivalent of limbs, but are merely superficial differentiations of the membrane surrounding the aperture of the oviduct.

It is not deemed appropriate to recall in this paper the reasons which have prompted the opinions here recorded. Yet it will not be useless, in order to render the task easier

to readers of the following descriptions, to draw an elementary sketch of a vulva and to make them acquainted with the terms which have been applied to the different parts of these puzzling organs.

The two branches of the oviduct are known to end behind the legs of the second pair and to be capped with vulvæ. In most of the Diplopod groups (*Colobognatha* and *Oniscomorpha* excepted), the vulvæ are concealed in a deep depression of the intersegmental membrane, which will be known as the vulvar "vestibulum." In some cases the vulvæ stand side by side in the vestibulum, while in some others they are sunk into independent, lateral invaginations of the vestibulum, apart from each other, (Fig. 3). The position of the vulvæ is therefore very different, according to the various cases; but whatever it may be, in order to make things obvious, a vulva is always considered isolated and standing with its free end upwards (as represented in Figs. 26 and 27, *Paraiulus pennsylvanicus*, for instance).

In condition of rest, the terminal region of the oviduct may be compared to a funnel which has been pressed flat, causing the aperture to be linear and perpendicular to the main axis of the body. Immediately behind the aperture the neighboring surface is raised into a more or less projecting and rounded, always very conspicuous jutting, called the "mound." Its lateral slopes are protected by chitinised plates, reminding one of the shells of a Lamellibranch, and consequently termed the (inner and outer) "valves," (*iv*, Fig. 26). An apical space, the "ridge," (*r*, Fig. 27), is left between the valves, made of colorless chitine, below which is to be seen a longitudinal chitinous, gutter-shaped thickening, the "apodema," (*a*), extending perpendicularly to the aperture of the oviduct. The apodematic gutter communicates with the exterior by means of a longitudinal "slit," which divides the ridge into more or less regular halves.

In some cases the posterior ends of the valves remain free, the ridge being open backwards; in the case of Iulids, the valves are generally connected by, and often fused with a posterior-median plate, the anterior margin of which is emarginate and thickened in shape of a horse-shoe ("horse-shoe plate"). The latter bounds the ridge caudad, (*h*, Fig. 27).

Further backwards, behind the mound, a plate of very variable size and form may be observed, which is known as the "shield." It is not unusually found amongst Polydesmids, Chordeumoids or Spirostreptoids, but has only been met with in a single Iuloid Diplopod, *Mesoblaniulus serrula*, and its existence in *Paeromopus* is highly interesting, (*s*, Figs. 4, 8, 9).

Cephalad the mound is fenced in by the posterior wall of the oviductal funnel; its anterior end is therefore flattened and may be spoken of as the "anterior truncation."

In front of the oviductal aperture is a more or less thickly chitinised, erected plate (*o*, Fig. 5, 26, etc.), the posterior surface of which is lined by the anterior wall of the funnel. Its outline is variable and made to fit the anterior truncation of the mound, whence the name "operculum" used for it.

As a matter of fact, the vulvæ are by no means as simple as could be inferred from the above rough sketch; but the latter will, perhaps, be sufficient from a morphological point of view, and readers interested in further details will kindly refer to Brolemann & Lichtenstein's paper of 1919. Yet a few more words have to be devoted to a structure exceptionally met with in some American species.

When the vestibulum is deep enough to conceal the vulvæ and to allow the third segment to meet the second above them, the operculum has very little importance as a protective plate (see *P. tiganus*). But when the summit of the vulva is on a level with the ventral surface, the operculum is made to shelter the mound from external contacts. For instance, in contradiction with what has been so far observed in other groups, the operculum of some of the species hereafter recorded is by far the largest plate of the vulva, the most interesting cases being those of the *Paraiuli* of the *impressus* group. In these species the vulvæ are coupled, the opercula of both vulvæ having become coalesced into an uncommonly large, tectiform plate, erected perpendicularly to the main axis of the body (*y*, Figs. 39, 46, etc.), the only trace of fusion left being a notch in the apical ridge; consequently this plate will be spoken of as a "synoperculum." The mounds are located laterally in distinct, symmetrical dimples bounded distally and inwardly by diagonal edges of the operculum, delineating between them and the apical ridge a raised, triangular or heart-shaped space,

projecting caudad ("heart-shaped projection").* The outline of the synoperculum, the depth of its apical notch, the size of the heart-shaped projection are different in each species and supply good criteria for the identification of adult females.

Before entering into further details as to each particular case, some of the general features of the species under consideration may be mentioned. In *Paeromopus* the ventral duplicature of the mandibular stipe is short and more or less angular, while in *Paraiulus* it is produced into a rounded lobe, reaching about half the length of the cardo. Ralph V. Chamberlin has published a drawing of the gnathochilarium of a male *Paeromopus lysiopetalinus* (Ann. Entom. Soc. Amer., III, No. 4, 1910, Pl. XLIII) which agrees almost entirely with our own, except that no plates are represented between the gula† and the base of the stipes. In Californian ♂ and ♀, *P. Chamberlini*, as well as in ♀ *P. lysiopetalinus* (Fig. 1), two symmetrical narrow stripes are found, considered to represent the intermentum. However, a sexual dimorphism might account for this discrepancy and the matter has therefore to be investigated anew. The postmentum is constantly missing.

It has already been stated, 1902, that an intermentum and a postmentum exist in both sexes of *Paraiulus*. However, a detail was at that time left unmentioned, i. e., that the postmentum, which is independent in males, is fastened to the gula in females, the caudal margin of the former being fused with the dorsal concavity of the latter, as shown in Fig. II and III. In the *Blaniulidæ*, which are European representatives of the *Paraiulidi* phylum, the intermentum and the postmentum are both present, the latter always remaining independent, but being entire (*Blaniulinæ*) or divided into two plates (*Isobatinæ*). The female *P. pennsylvanicus* examined combines the two structures, as the postmentum is divided, as in *Iso-*

*The origin of the "heart-shaped projection" will probably have to be sought for in the "hood" of *Paeromopus*. While in the latter it has become an almost independent plate through the effects of long lasting rectigradation, in *Paraiulus*, it has not reached the same grade of achievement owing to reasons still to be ascertained, but likely to be connected with Neotenia.

† Since his paper, 1902—Ann. Soc. Entom. France, LXXI—the author has been induced to accept the terms proposed by Verhoeff for the parts of the gnathochilarium. Consequently what was named mentum, hypostoma and ventral plate I in said paper, is now the intermentum, the postmentum and the gula.

batinæ, and yet is attached to the gula, as in other species of *Paraiulus*.

In female *Paraiuli*, the second segment and the third are more or less swollen in accordance with the size of the vulvæ. The second segment is generally produced ventrad, the ventral margins of the tergo-pleural arch being twisted (Fig. 12, a) and bearing the so-called ventral lobes (*l*). On the surface of the twisted part occurs a transverse "ventral ridge" (n), surrounding cephalad a large and shallow dimple (*u*). According to species the ventral ridge is more or less irregularly curved, the dimple resulting broader or longer. The third segment shows a still more irregular structure, as it sometimes tapers ventrally (*tiganus*), and sometimes grows longer (*impressus–venustus*); the ventral lobes may likewise be very different or much reduced.

In *Paeromopus* (♂ and ♀), the ventral region of the three anterior, thoracic segments present a more simple structure, deemed to be archaic. The duplicatures of the collar lobes are more narrow and their angles are evenly rounded (not notched). No ventral lobes are found on the two following segments, the margins of which are diagonally converging backwards, the posterior angles being acute. Under contraction (Fig. 54), the three segments are forced into one another, their ventral margins uniting to build an oval frame, which is closed backwards by the sternal plate of the fourth segment, and in which fit the head with the mouth-parts, the limbs of the first and second pairs and the sexual apertures (vulvæ or penis) closely packed together. An exceptional case is likewise found in *Paeromopus*, as the sternite of the third pair of legs is not fused with the fourth tergo-pleural arch, as usual, but freely articulates with it, a condition realized in the Japanese genera *Karteroiulus* and *Kopidoiulus*.

In all cases the limbs of the first pair remain independent and show no striking particulars; the sternite is usually missing (Fig. 2). The limbs of the second pair are preserved in *Paeromopus* (Fig. 3), and are not coalesced; the sternal plate is scarcely chitinised and only between the stigmata, which are membranous dimples; the tracheal stalks are very long and slender, ribbon-shaped, bent backwards and outwards. The coxæ are represented by their basal expansions only, the cylindrical part missing altogether and the telopodites articu-

lating on the inner angles of the basal expansions. The following joints show the normal structure of the ambulatory legs. The vulvar vestibulum is a wide depression closed by five folds made of tough membrane; of these, two anterior symmetrical folds (1, 2) run parallel with the basal expansions of the coxæ, while two lateral symmetrical folds (3, 4) connected by a fifth median odd fold (5) surround the aperture backwards. On each side of the vestibulum are deep invaginations (*i*) in which the vulvæ are concealed.

In *Paraiulus* the conditions change according to the groups, *tiganus* namely being strikingly different from the other species in respect of vulvæ, and until more material has been examined, no general diagram can be proposed. It seems, however, that the vulvar vestibulum is less developed, that the vulvæ are never hidden in independent invaginations and stand side by side on the middle line, and that the limbs of the second pair have always undergone a more or less advanced reduction, disappearing even entirely in some cases (*immaculatus–pennsylvanicus*).

In a larval stage of *Paraiulus*, supposed to be the last, the second pair of legs constantly has been found to exist, (Figs. 19, 20); but it differs from the ambulatory legs in that the basal coxal expansion is narrower and the cylindrical part is longer than usual.

Genus **Paeromopus** Karsch, 1881.

Paeromopus lysiopetalinus Karsch, 1881.

(Fig. I and 1-5).

♀. Length 133 mm.; diameter 7.25 mm.; 75 segments, of which 1 apodous; 143 pairs of legs.—Adult.
♀. Length 142 mm.; diameter 7.96 mm.; 73 segments, of which 1 apodous; 139 pairs of legs.—Adult.
♀. Length 144 mm.; diameter 6.80 mm ; 73 segments, of which 2 apodous; 137 pairs of legs.—Adult.
Sonoma County, California.

These specimens do not entirely agree with Karsch's description; the fact that the type is a large male, measuring 150 mm. with 80 body segments, may account for the discrepancies.

Color a very dark brown, with brownish limbs; clypeus fulvous; metazonites adorned between the pores with orange transverse bands. Body narrowed anteriorly, the diameter of the seventh segment being 5.20 mm., that of the 24th segment 6.80 mm. Yet the second and third are more swollen than the neighboring segments.

Clypeus transversely wrinkled or rugose. Antennæ reaching as far back as the fifth segment; comparative measures of the joints as follows:

1st joint, length	0.559 mm.;		
2d joint, length	1.978 mm.;	diameter	0.752 mm.
3d joint, length	2.193 mm.;	diameter	0.709 mm.
4th joint, length	1.935 mm.;	diameter	0.623 mm.
5th joint, length	1.768 mm.;	diameter	0.645 mm.
6th joint, length	1.333 mm.;	diameter	0.645 mm.
7th–8th joints, length	0.301 mm.		
Total length	10.062 mm.		

Mandibular stipe short, scarcely longer than the cardo (Fig. 1); mandibula much higher than broad, with numerous pectinate lamellæ (12 to 14). Intermentum present, divided; postmentum wanting, the gula showing a single ventral ridge, (Fig. 1).

First segment coarsely punctured dorsally; lateral lobes small, acute, with some 8 or 10 thin, shortened sulci closely packed together in the angle of the lobe. Second segment showing coarse punctures intermingled with faint longitudinal sulci dorsally, the punctures disappearing laterally, while the sulci grow deeper. Following segments distinctly sulcate even dorsally, with only few punctures along the posterior margin, the latter disappearing gradually backwards. First pore on the sixth segment, opening in front of, but close to the suture; further caudad the pores open behind the suture in the center of a small, smooth, indistinctly raised area. Segments without marginal fringe. Karsch devotes a special mention to some depressions to be seen on the segments behind the 18th, which have not been observed.

Legs of the first and second pairs comparatively short. First sternal plate membranous; coxæ of first pair expanded laterally with a slightly sinuous outer margin, and without a cylindrical apical part (Fig. 2). Second sternal plate scarcely chitinised between the stigmatic membranous dimples; tracheal stalks very long and slender, ribbon-shaped; coxæ of second pair similar to those of the first, but somewhat shorter.

Vulvæ concealed in lateral, broad and moderately elongate, invaginations, their summit being on a level with the bottom of the vestibulum (Fig. 3). The operculum, in its anterior aspect, appears as a triangular plate strewn with short setæ, the lateral margins of which are bent back perpendicularly, the outer more than the inner. It is tipped with a peculiar, hood-like appendage (*c*, Figs. 4, 5), laterally compressed, overlapping the mound and bearing few setæ.

The mound is protected laterally by oval valves moderately pilose, standing vertically (*ov*). Their upper angles are connected by what appears to be (in posterior aspect) a thick, strongly chitinised, quadrangular pad (*h*), which is the basal end of the horseshoe plate. The upper forks of the latter, as well as the ridge lying between them, are bent forwards so as to face the concavity of the operculum, thus assuming the position of the anterior truncation. The ridge is wide,

lobed cephalad, and divided by a slit which is narrow anteriorly, but abruptly widens backwards. The apodematic gutter (*a*) is moderately elongate and bears numerous loops and two apical, small, globular diverticula (*d*).

The space left free between the valves and behind the horseshoe plate is filled by a plain, subquadrangular plate (*s*) somewhat broader than long and slightly convex, equivalent to the shield of some *Polydesmus;* its upper margin slightly encroaches on the posterior margin of the horseshoe plate, but does not seem fit to cover completely the plate.

Paeromopus chamberlini, n. sp.

(Fig. 6—9).

♀. Length about 84 mm.; diameter 5.10 mm.; 68 segments of which 2 apodous; 127 pairs of legs.—Adult.
Mt. Shasta, California.

Resembles the preceding species in many features such as relative length of the clypeus and of the antennæ, structure of the gnathochilarium, of the anterior body segments, of the first pair of legs, etc.*

The mandibular stipe is not much longer than the cardo (Fig. 6); it is gradually narrowed anteriorly, the apical angle being slightly produced and acute.

Lateral expansions of the coxæ of second pair much developed (Fig. 7), strongly and evenly arched. The cylindrical part entirely missing. The posterior surface is unusually callous paramesally (*y*) and strongly projects backwards, hanging over the aperture of the vestibulum. The vulvæ appear spindle-shaped on the whole (Fig. 8), being more restricted proximally than in *lysiopetalinus*. The main body of the operculum show no special structure, but the hood (*b*) is larger and broader, more sharpened apically and more expanded caudad, made to cover entirely the mound. The latter (Fig. 9) is longer than high, the valves are lower and more rounded, the horseshoe plate and the ridge are less bent forwards, more horizontal and only partly encroach upon the anterior truncation. The horseshoe plate (*h*) being angularly excised, the ridge is triangular; the slit is not broadened caudad. The apodematic gutter is rather short, depressed in the middle, provided with two short diverticula (*d*); the anterior diverticulum is irregularly swollen and sitting, while the posterior is globular and borne on a short, slender stalk.

The shield (*s*) is as broad as the mound, strongly convex, with rounded base and straight distal margin. The membranous connection between the shield and the horseshoe plate being wide, the shield is admitted to glide over the mound and join the hood of the operculum, the ridge thus becoming entirely hidden from view.

* Further details to be found in the description of the male given "*in fine.*"

Genus **Paraiulus** Humbert & Saussure, 1869.

Paraiulus tiganus Chamberlin, 1910.

(Figs. II and 10-21).

♀. Length 37 mm.; diameter 2.44 mm.; 56 segments, of which 2 apodous; 102 pairs of legs.—Adult.

♀. Length (?); diameter 2.48 mm.; 55 segments, of which 2 apodous; 100 pairs of legs.—Adult.

♀. Length (?); diameter 2.44 mm.; 55 segments, of which 2 apodous; 100 pairs of legs.—Adult.

♀. Length 39 mm.; diameter 2.38 mm.; 54 segments, of which 2 apodous; 98 pairs of legs.—Adult.

♀. Length 29 mm.; diameter 2.05 mm.; 52 segments, of which 2 apodous; 94 pairs of legs.*—Immature.

Adult Female.—Interocular sulcus deeply impressed. Antennæ moderately elongate; comparative measures of joints as follows:

1st joint, length	0.192 mm.;	
2d joint, length	0.608 mm.; diameter	0.224 mm.
3rd joint, length	0.544 mm.; diameter	0.240 mm.
4th joint, length	0.512 mm.; diameter	0.240 mm.
5th joint, length	0.480 mm.; diameter	0.288 mm.
6th joint, length	0.448 mm.; diameter	0.272 mm.
7th-8th joint, length	0.192 mm.	
Total length	2.976 mm.	

Mandibular cardo (Fig. 13) equal to two-thirds of the stipe. Mandibular stipe short and broad (ratio: l. 6 x b. 5), rounded anteriorly. Promentum entirely dividing the laminæ linguales; the latter bear six setæ in a longitudinal row, besides the usual premarginal bristle.

Second and third segments (Figs. 10, 11) conspicuously swollen. Profile of second segment angular; ventral ridges low (Fig. 13), almost regularly curved; dimples oval, broader than long; ventral lobes large, over-lapping each other. Third segment tapering ventrally, with profile scarcely convex. Anterior aspect as in Fig. 13, B.

Legs of second pair much reduced (Fig. 14). The sternite (*S*) is a short but broad stripe, with posterior margin straight and outer angles unusually produced. Tracheal stalks more or less developed. The six joints of the limbs are preserved, all except the two distal joints being shorter than broad; first joint almost completely fused with the sternal plate; last joint oval, tipped with a spine-like claw.

Vulvar vestibulum moderately deep, with a wide aperture not constricted by symmetrical folds, fastened to the duplicatures of the third segment and to the anterior margin of the fourth. The vulvæ sit at the bottom of the vestibulum side by side, the operculum facing externally and somewhat forwards.

The mound is a very low, semi-cylindrical body, the walls of which represent the horseshoe plate probably fused with the valves (Figs. 15, 18). The inner region of the wall is more raised and more convex than the outer, causing the mound to be asymmetrical, with the ridge

* The last leg-bearing segment has but a single pair of limbs.

gently sloping outwardly. An abbreviated sulcus is seen on each side of the wall, running close to, and parallel with the anterior truncation, which is rather broad. The apodema (*a*) does not exceed the second third of the ridge; it is deeper in the middle than at both ends and sends forth a median, club-shaped, and an apical, strangely hooked diverticulum (*d*, Fig. 15, 18). The operculum (*O*) is a quite unimportant plate, the form of which is not even definite, as in one of the specimens examined it was scarcely chitinised, while in another no trace of chitinisation could be observed, the operculum being represented by a soft membranous fold.

Immature Female.—In an immature female (Fig. 19, 21), the sternal plate of the second pair of legs is three times broader than long in the middle, slightly arched, with the median angle scarcely produced. The immature vulvæ (*W*, Fig. 19) sit on a membrane stretched behind the second pair of limbs, on a level with the laterally reflexed ends of the sternite. Each vulva is formed of three rounded swellings disposed diagonally, the anterior-outer swelling (*O*, Fig. 21) being the operculum, the anterior-inner (*iv*) representing the inner half of the mound, and the posterior (*ov*) the outer half. A rudimentary conic apodema (*a*) is to be observed between the two last mentioned swellings.

It is well worth insisting upon the features of the vulvæ of *P. tiganus*, as not only the condition of the operculum is decidedly exceptional, having never been met with before, but the aspect of the whole organ is so different from what will be found in the following species, that the relationship between the latter and *tiganus* appear very distant, as far as vulvæ are concerned.

Paraiulus pennsylvanicus (Brandt, 1840), Wood, 1865.

(Fig. 22–27).

♀. Length 39 mm.; diameter 2.25 mm.; 64 segments, of which 2 apodous; 118 pairs of legs.—Adult.

♀. Length 34 mm.; diameter 2.15 mm.; 60 segments, of which 2 apodous; 110 pairs of legs.—Adult.

Interocular sulcus moderately impressed. Mandibular cardo (Fig. 24), shorter than in *P. tiganus*, about two-fifths of the length of the stipe. Breadth of the stipe equal to two-thirds of its length; anterior and ventral edges unite in an evenly curved line without any trace of an anterior angle. The promentum thins out apically, the laminæ linguales being almost in contact; the latter bear a row of three to four short setæ and two premarginal long bristles.

Anterior body segments almost cylindrical, the diameter of the second segment is only a little larger than that of the head (Fig. 22, 23). Profile of the second segment rounded; ventral ridges raised; dimples more or less angular and subquadrate (Fig. 25, *A*); ventral lobes broad, encroaching on each other. The third segment is not shortened

ventrally; the inner pleural margins are thickened; to their posterior angles are attached flattened lobes, twisted perpendicularly, which overlap each other; the anterior angles are produced into strongly chitinised hooks bent dorsally (Fig. 25, *B*). The upper ends of the hooks are connected by a tough membrane, stretched perpendicularly, in the middle of which are found the relics of the atrophied sternite of the second pair of legs (*P2*). These relics consist of a subreniform, irregularly chitinised, transverse plate, with no definite outline, showing traces of stigmata and of tracheal stalks; the limbs have disappeared altogether.

The space left between the membrane and the ventral lobes is filled with vulvæ. The vestibulum could not be observed, being probably shallow. The vulvæ stand side by side, connected by soft membrane, with the operculum facing cephalad. The general appearance of a vulva is that of a truncate spindle or of a tiny cask. The operculum is flattened, oval in outline, and bears macrochaetæ disposed in four longitudinal rows, two lateral and two paramedian rows, the latter converging proximally. The valves (*iv*, Fig. 26), are almond-shaped, with a median row of bristles, and stand erect. The central part of the mound, i. e., the horseshoe plate and the ridge framed by its branches, are strictly comparable to the mound of *tiganus*, which would have undergone a caudal rotation of 45°, causing the ridge to face fully backwards (Fig. 27). Ridge oval. The slit divides the summit of the mound and part of the ridge into fairly symmetrical halves. The apodema is short, but ends in an extremely long, slightly sinuous, tubular diverticulum.

Paraiulus immaculatus Wood, 1864.

(Fig. 28-34).

♀. Length 36 mm.; diameter 2.65 mm.; 51 segments, of which 2 apodous; 92 pairs of legs.—Adult.

♀. Length 31 mm.; diameter 2.10 mm.; 51 segments, of which 2 apodous; 92 pairs of legs.—Adult.

Interocular sulcus not impressed. Antennæ moderately long, not exceeding the fourth segment; comparative measures of joints as below:

1st joint, length	0.160 mm.;		
2d joint, length	0.544 mm.;		
3d joint, length	0.480 mm.;		
4th joint, length	0.448 mm.;		
5th joint, length	0.416 mm.;	diameter	0.208 mm.
6th joint, length	0.352 mm.;	diameter	0.224 mm.
7th-8th joint, length	0.128 mm.		
Total length	2.528 mm.		

Mandibular cardo (Fig. 30) about equal to three-fourths of the stipe, the latter being longer than usual, and rounded anteriorly. Mandibula furnished with 8 to 9 pectinate lamellæ. Promentum

narrow, shorter than the laminæ linguales, the inner angles of which are almost in contact. Each lamina bears two setæ and two premarginal bristles.

Anterior segments not obviously swollen (Figs. 28, 29). Ventral region of second and third segments produced far beyond the collum. Second segment with posterior margin raised and abruptly excised, and with short, triangular ventral lobes. Ventral ridge strong, almost angularly bent; the dimples are broader than long and stretched diagonally (Fig. 31, *A*). The third segment is not narrowed ventrally; its pleural margins are excised, the posterior angles ending into short, ventral lobes, the apex of which remain separated by a wide gap (Fig. 29). The anterior angles send forth rounded processes which are connected by a chitinous bridge (*P2*), homologous with the sternite of the second pair of legs. The sternal bridge shows traces of the stigmata and of the tracheal stalks, the limbs being completely atrophied.

The sternal bridge, the pleural excision and the ventral lobes of the second segment circumscribe an oval space through which the summit of the vulvæ is seen to protrude. Wood (1865, p. 200, Fig. 33) has given a drawing of the vulvæ of *immaculatus*, which gives a correct idea of their general aspect. The vulvæ stand side by side and cling together, although no fusion seems to intervene (Fig. 32). The operculum is a thick, subquadrangular plate, more than twice as high as broad, with blunt angles; the bristles of the anterior surface are rare and only to be found near the apical margin. On its posterior surface a thickening is seen adjacent to the inner distal angle and projecting above the ridge of the mound (*H*, Figs. 32, 33). The latter is extremely asymmetrical. Seen in posterior aspect, the outer valve (*ov*) appears as a triangular plate gradually narrowed proximally and truncate distally, the distal margin being about half the length of the plate; it leans inwardly so as to cover most of the posterior surface of the organ. The inner valve (*iv*) is more like a subcylindrical pillar, much lower than the outer valve; yet its base being on a level with the center of the outer valve, its summit considerably exceeds the apical truncation of the latter and almost reaches the top of the operculum. No horseshoe plate is present, unless an apical thickening of the outer valve, which connects it with the inner valve, be considered to be its homologue. The ridge is hidden to view, being bent cephalad and dipping obliquely towards the base of the organ (Fig. 34). The apodema is very short and sends forth a comparatively small, pear-shaped diverticulum.

The sternal plate of the third pair of legs has a special shape, different from that of the other segments in having the anterior angles produced laterally and the sides sinuous.

It is noteworthy that, in *immaculatus*, conditions are similar to those met with in *tiganus*, in so far as the vulvar chamber has a rigid aperture supplied by the third segment. However, the comparison cannot be carried on any further as the vulvæ

widely differ in both species, *immaculatus* more approaching those hereafter dealt with. In spite of the special form of its mound, the relationship can be traced in the structure of the operculum, the subapical thickening of which is undoubtedly a preliminary stage of the heart-shaped projection of the synoperculum of *impressus*.

Paraiulus impressus Say, 1821.

(Fig. 35–42).

♀. Length 33 mm.; diameter 2.20 mm.; 53 segments, of which 2 apodous; 96 pairs of legs.—Adult.
♀. Length 26 mm.; diameter 1.77 mm.; 53 segments, of which 3 apodous; 95 pairs of legs.—Immature.
♀. Length 25 mm.; diameter 1.78 mm.; 53 segments, of which 3 apodous; 95 pairs of legs.—Immature.

Adult Female.—Interocular sulcus slightly depressed. Antennæ about the same length as in *immaculatus*, but comparative measures of joints somewhat different:

1st joint, length	0.160 mm.;		
2d joint, length	0.576 mm.;		
3d joint, length	0.512 mm.;	diameter	0.208 mm.
4th joint, length	0.448 mm.;	diameter	0.208 mm.
5th joint, length	0.480 mm.;	diameter	0.240 mm.
6th joint, length	0.416 mm.;	diameter	0.256 mm.
7th–8th joint, length	0.128 mm.		
Total length	2.720 mm.		

Gnathochilarium as in *tiganus*, but less narrowed proximally (Fig. 38); laminæ linguales bearing three setæ besides the premarginal pair. Mandibular cardo about two-thirds of the stipe; breadth of mandibular stipe about four-fifths of its length; anterior margin truncate, with lower angle obvious (Fig. 35).

Second and third segments much swollen (Figs. 35, 36), their ventral surface protruding far beyond the angles of the collum and appearing rounded in profile. Ventral ridge of second segment less sinuous than in the preceding species; dimples as high as broad, almost triangular; the ventral lobes remain disjoined (Fig. 37, *A*). Third segment growing longer ventrally; inner margins almost straight, converging backwards, with rounded anterior angles and short ventral lobes, reflexed and prominent. Ventral aperture wide, filled by the vulvæ, which are never completely concealed (except in contracted condition of the animal).

A rough sketch has already been given in the preceding chapter. The synoperculum sits on a broad base and is narrowed distally, its apical margin being equal to about half its base (Figs. 39, 40). The dwarfed legs of the second pair (*P2*) are attached to its anterior surface, no sternal plate being recognizable; the legs are composed of six joints

shorter than broad, their apex not overreaching the distal margin of the synoperculum. The latter is interrupted mesad, the notch being comparatively narrow and shallow. The heart-shaped projection (*H*, Fig. 40) is slightly impressed longitudinally in connection with the notch; its lateral edges are attenuate and unite proximally with a low, flattened, perpendicular keel, dividing the basal excavations.

The mound (Figs. 40, 41) is a globular, asymmetrical body, entirely clad with the valves, which are fused with the horse-shoe plate and only connected caudad by a narrow, not particularly chitinised bridge. The inner valve is the longest; it is inflated caudad, its upper margin being feebly lobed; cephalad is a low, sharpened, diagonal crest (*c*). The outer valve is divided anteriorly by a wide perpendicular furrow (*w*), the bottom of which is membranous, the valve being conspicuously gibbous immediately backwards of the furrow. The upper margins of the valves are pressed together, concealing the ridge. The apodematic gutter (*a*, Fig. 41) is located in the anterior half of the mound; it appears distorted by numerous loops and terminates in a long and comparatively thick, gradually tapering diverticulum.

Ventral region of the fourth segment, as in Fig. 37, *B*.

Immature Female.— In a larva of the last stage, the mandibular stipe is gently narrowed anteriorly and rounded apically. The second and third segments are neither swollen nor produced ventrad; the third is very different from what it is in adult and more approaches the condition of the second segment, being even shorter than the latter. The main points of the structure of the second pair of legs have already been recorded.

The immature vulvæ (Fig. 42) are considerably more developed than in the *tiganus* larva, being broader than the second sternite, and several details being noticeable. The opercula have already coalesced, their evenly arched upper margins uniting mesad and giving rise to a wide angular notch; on each side of the notch the posterior surface of the synoperculum shows the raised area which, in the adult organ, will be fused in a heart-shaped projection. The mounds are broader than high and of comparatively much larger size than in the adult; yet no other detail of their structure is obvious but a rudimentary apodematic thickening.

Paraiulus venustus Wood, 1864.

(Fig. 43–50).

♀. Length 33 mm.; diameter 2.45 mm.; 51 segments, of which 2 apodous; 92 pairs of legs.—Adult.

♀. Length 33 mm.; diameter 2.42 mm.; 50 segments, of which 2 apodous; 90 pairs of legs.—Adult.

♀. Length 25 mm.; diameter 2.05 mm.; 51 segments, of which 2 apodous; 93 pairs of legs.—Immature.

Adult Female.—Resembles *impressus* in most of its features. Antennæ as below:

1st joint, length	0.224 mm.;		
2d joint, length	0.544 mm.;	diameter	0.208 mm.
3d joint, length	0.512 mm.;	diameter	0.208 mm.
4th joint, length	0.448 mm.;	diameter	0.208 mm.
5th joint, length	0.448 mm.;	diameter	0.240 mm.
6th joint, length	0.432 mm.;	diameter	0.256 mm.
7th–8th joint, length	0.096 mm.		
Total length	2.704 mm.		

Mandibular stipe truncate, but scarcely angular below. Lateral lobes of first segment not evenly rounded, a posterior angle being obvious. The second and third segments are appreciably more swollen, in relation with the larger size of the vulvæ (Figs. 43, 44). The posterior ventral margin of the second segment is raised and rounded, causing the ventral dimple to be almost as long as broad, trapeziform (Fig. 45, *A*). The third segment is much longer ventrally than dorsally; the inner pleural margins are parallel and nearly straight; but the ventral lobes are so small and so widely separated that the vulvar aperture is practically open backwards and reaches as far back as the fourth segment, (Fig. 44).

The vulvæ are uncommonly large (Fig. 46, 47). H. C. Wood (1865, p. 197, Fig. 29) has issued a description and a drawing of these organs which, though reduced are perfectly appropriate; yet he fails to mention that the "flattened cylinders" are coalesced. Compared with the similar organ of *impressus*, the synoperculum is more quadrate, its outer margins being perpendicular (slightly emarginate) and its breadth hardly different distally and proximally. The median notch is larger, with rounded bottom. The edges of the heart-shaped projection (*H*, Fig. 47) are considerably expanded into broad, flattened triangular lobes, reaching laterally the outer margins of the synoperculum and overlapping the distal half of the excavations in which the mounds are sheltered; the outer margins of the lobes converge towards the base of the synoperculum without meeting, entirely disjoining the mounds.

The "pair of very slender, almost filiform, feet-like bodies" mentioned by Wood in connection with the synoperculum, are the atrophied limbs of the second pair which are fastened to its anterior surface. As in *impressus* the six joints are preserved, being broader than long and of irregular size. In addition a small sternal plate was present in the specimen examined.

The lateral outline of the mound reminds of a crescent, the lower, rounded end of which is abruptly bent inwardly below the mound (Fig. 48). A narrow cleft divides the organ into two subequal halves, which are only connected caudad by the reflexed end of the crescent (*h*, Fig. 49), this being equivalent to the horse-shoe. No dividing sulcus exist between the latter and the valves. Cephalad each valve bears a sharp diagonal crest, both crests meeting at the anterior end of the crescent. The anterior region of the inner valve which faces

the synoperculum is poorly chitinized, but lacks the furrow observed in *impressus*. The apodematic gutter (*a*) is by one-third shorter than the mound; it appears distorted by numerous, densely packed loops and terminates caudad with a long, rod-like diverticulum, bent at right angles near its base and clavately enlarged apically (*d*).

The sternite of the third pair of legs is unusually widened cephalad, its breadth largely exceeding half the diameter of the segment (Fig. 45, *B*).

Immature Female.—In a larva admitted to belong to the last stage, the mandibular stipe is rounded in front, no trace of inferior angle being obvious. The second segment has its ventral margins less produced. The third is quite different from the corresponding mature segment, as it is gradually narrowed ventrally, the inner margins running obliquely in the lobes, very much as in the second segment. The second pair of limbs is unmodified, i. e., it shows the structure of the ambulatory legs, except that the coxæ are longer, as is the case with larvæ of other species.

The immature vulvæ (Fig. 50) remind of those of *impressus*, as the opercula are low, transverse plates, with distal margin gently arched, but not fused mesad. The mounds appear as half-moon-shaped bodies, divided by a shallow depression, with a linear slit and rudiments of the horse-shoe and of a digitiform diverticulum.

Paraiulus ellipticus Bollman, 1887.

(Brolemann, 1896-1902).* (Figs. 51, 52).

Gnathochilarium as in *pennsylvanicus*. The twisted ventral lobes of the third segment are very prominent ventrad. A rough outline of the anterior aspect of same and of one of the limbs of the second pair has been published in 1902. Traces of the second sternite are preserved.

Synoperculum very deeply split mesad (Fig. 51); on each side the distal margin is slightly curved and sloping laterally, being in addition strewn with tiny setæ. Lateral margins sinuate, prominent at a short distance from the base. Heart-shaped projection (*H*) somewhat as in *venustus*, its edges being likewise expanded into flattened lobes, but the latter remaining far apart from the outer margins of the synoperculum; the lobes converge abruptly, uniting in a ploughshare-like process (*x*) bent cephalad and driven between the summit of the mounds (*M*), the bases of which remain in contact. The valves of the mound are very dissimilar, the outer (*ov*, Fig. 52) being somewhat higher and appreciably shorter than the inner, causing the ridge to face obliquely backwards and externally. The ridge (*r*) is wide and divided by a conspicuous slit. The apodematic gutter is comparatively short, dipping perpendicularly, provided with some rounded loops and with a fairly long diverticulum, much as in *venustus*.

* This specimen being no longer in the author's collection, the secondary structures had to be omitted.

Description of a New Species.

Paeromopus chamberlini n. sp.

(Figs. 53–57).

♂. Length about 111 mm.; diameter 4.60 mm.; 79 segments, of which 1 apodous; 149 pairs of legs.—Adult.

♂. Length about 93 mm.; diameter 5.12 mm.; 71 segments, of which 2 apodous; 131 pairs of legs.—Adult.

Mount Shasta, California.

Pleural regions black, or at least very dark brown; a broad lively orange band runs dorsally from the first tergite to the last, almost entirely filling the space between the pores; the band thins out anteriorly; posteriorly it covers the margins of the anal valves. Clypeus fulvous, with yellow margin. Limbs brownish.

Labral plate very obvious, the anterior margin of the clypeus being somewhat swollen; mesal notch deep. Clypeus elongate, almost three times the length of the epicranium; surface rather flattened, leathery, with but few setiferous punctures, of which a pair stands in a line with the antennæ. Epicranium unusually short, longitudinally rugose, divided by a distinct sulcus. A less marked transverse sulcus connects the inner angles of the eyes; behind, and in contact with it is the usual pair of setiferous dimples which is formed by coupled punctures. Antennæ long, yet not extending over the fourth segment; measures of joints as below:

1st joint, length	0.256 mm.;		
2d joint, length	1.344 mm.;	diameter	0.544 mm.
3d joint, length	1.728 mm.;	diameter	0.544 mm.
4th joint, length	1.440 mm.;	diameter	0.448 mm.
5th joint, length	1.374 mm.;	diameter	0.480 mm.
6th joint, length	1.184 mm.;	diameter	0.480 mm.
7th–8th joint, length	0.192 mm.		
Total length	7.518 mm.		

Ocelli distinct, numbering about 22 (7, 6, 5, 4), collected on a subtriangular field. Mandibular stipe (Fig. 53) almost quadrate, not longer than high, produced ventrally and with its anterior angle somewhat angular. Gnathochilarium as in female *lysiopetalinus*, i. e., with intermentum and without postmentum.

Collum strewn dorsally with numerous, moderately coarse punctures. Lobes small, angular, marked with four or five short and thin sulci. Following segments very much as in *lysiopetalinus*, the metazonites bearing sulci intermingled with punctures; sulci strongly impressed anteriorly, less deep but more numerous backwards. First pore on the sixth segment; the five or six anterior pores are located behind, and in contact with the suture, which is slightly sinuous; further caudad the pores and more and more removed from the suture, so as to open in the first and third of the metazonite. Last tergite very short; its posterior margin is thick and scarcely produced, leaving uncovered the

dorsal angles of the anal valves. The latter are moderately prominent, much higher than long, scarcely rugose, with a tiny irregular sulcus close to the inner margin. Anal sternite with apex truncate. Sternites with a transverse groove behind the middle. Legs elongate; the ventral surface of the second joint is fleshy, appearing generally excavated, and the fifth joint is provided with an angularly produced pad, both structures being found on almost all the legs.

The legs of the first pair are not unlike those of *lysiopetalinus* (Fig. 55). The basal joint is a very short ring, curiously excised posteriorly (*C*), provided with a short tracheal stalk; outwardly a small rounded plate is seen (*S*), admitted to be all that is left of the sternite, the first joint thus being a coxa. The second joint is still shorter and open externally. The remaining joints of the limb are fused into a short and stout cone, tipped with a hook coiled cephalad and divided on its posterior surface by two superficial transverse sulci, which do not extend on the opposite surface. Legs of the second pair with almost completely atrophied sternite; coxal joint subcylindrical, destitute of basal expansion. The following joints show no particular structures, the telopodite being merely shorter than in the ambulatory legs. Penis small, parallel sided on most of its length, apically divided into a pair of abruptly sharpened cones.

Peltogonopods (i. e., anterior pair of gonopods, Fig. 56) resembling those of *lysiopetalinus*. The very short sternal band (*S*) is fused with the long and flattened tracheal stalks (*t*). Coxal joint very long (*C*), gently tapering distally, its apex being pear-shaped and provided with two small hooks directed cephalad. The basal half of its inner edge bears an inconspicuous, short and blunt, retroflexed projection. Apical joint (*T*) as long as the coxa, fastened to the lateral edge of the latter in a manner that its basal, narrowed end almost reaches the sternal plate, while its distal end exceeds the summit of the coxa by less than one-fourth of its own length. The distal end is shallowly depressed cephalad, with acute outer angle, and is provided with two conspicuous processes, an anterior very long and slender, stake-like process, the sharpened end of which is directed proximally, and an inner erected, slightly curved spine, expanded and toothed in the middle of its length.

Sternite of gonopods (*S*, Fig. 57) crescent-shaped, with a narrow median, erected rod thrust between the limbs. The latter are rectangular lamellæ, three times as long as broad. Above the very thick base, the anterior surface is abruptly and deeply excavated, and the outer margin is slightly notched, owing to the fact that the distal part of the margin lies over the proximal part instead of standing in a line with it. Such structures bearing evidence to the former existence of a joint, the proximal thickened region (*C*) has to be looked upon as a coxal ring, while the upper flattened region (*T*) is equivalent to a telopodite. The latter end with a shallow depression, the outer angle being rounded and the inner bearing two short, erected processes, an anterior hooked and an inner spined process. The presence of a seminal groove could not be ascertained.

The female structures have been described above. The larval stages are unknown.

The systematic position of the genus *Pæromopus* has long remained doubtful. Its features are so special that Bollman has been led to create for it the family *Pæromopidæ*, in which Karsch's genus stood alone. But the question of its affinities was not solved thereby. Silvestri, after having left the point undecided, 1896[1], finally, 1898, admits Bollman's family *Pæromopidæ* amongst his *Iuloidea*. So likewise does Pocock[2] who denies it a relationship with the *Blaniulidæ* and the *Isobatidæ*. Attems, in his arrangement of the so-called "*Protoiulidæ*," does not mention Karsch's genus[3].

That *Pæromopus* has to take place in the *Paraiulidi* phylum, will certainly not be contested; yet it has still to be decided if it has to stand with the *Paraiulidæ* or with the *Blaniulidæ*[4].

If considered separately, the male genitalia supply no positive criterium. However, since the vulvæ are somewhat better known, it seems that a clue may be obtained from their structure. It has been mentioned that the vulvæ of *Pæromopus*, provided as they are with a shield, are of a type not usually met with amongst *Iuloidea*. In fact the only species in which a similar structure has been as yet observed, is *Mesoblaniulus serrula* (Brol.), a tiny cave-dweller of the French Mediterranean coast, originally ascribed to *Blaniulus*. In a paper actually submitted to press[5], an abstract of which[6] appeared recently, the author has altered his first opinion mostly on account of the conditions of the vulvæ; consequently it has been brought to rank amongst the *Isobatinæ*. An identical reason will therefore justify an attempt to enclose *Pæromopus* in the same group, in which a new Tribe—*Pæremopini*—will have to be created for its reception. No objection against such a conclusion can be derived from the male genitalia of *Pæromopus*, as these show the structure constantly found existing in *Isobatinæ*, i. e., the preservation in the gonopods of a distinct coxal region, which is missing in *Blaniulinæ*.

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[1]Silvestri, 1896, Ann. Mus. Civ. Stor. Nat. Genova, (ser. 2) XVI, 26, III, 1896, and 1898, Ibid, (ser. 2) XVIII, 29 XII, 1897.

[2]Pocock, Ann. Mag. Nat. Hist., (7) XII, No. 71, Nov. 1903, p. 527.

[3]Attems, Arkiv. for Zool., Stockholm, 1909, V, No. 3.

[4]According to the author's system, the *Blaniulidæ* are divided into two subfamilies, *Blaniulinæ* and *Isobatinæ*.

[5]This paper was ended during the spring, 1921, but could not be issued owing to the adverse conditions.

[6]Arch. Zool. exper. gen., LX, Notes et Revue, No. 1, 1921.

Of course the point under discussion will have to be re-examined when the American *Isobatinæ* and the Asiatic fauna will have become better known. Amongst the Japanese Diplopods already recorded is Attems' genus *Karteroiulus*, the male of which has the fourth segment open, whereas it is fused with the corresponding sternite in the female. But judging from the rough outline published by Attems (l. c., Pl. 2, Fig. 34), the vulvæ seem more closely related to those of the *impressus* group, as the "auf der Oralseite aufgeschlitzen Chitinring" probably answers halves of the synoperculum described in the preceding pages. Nothing is known of the female *Kopidoiulus* Att., the male of which is said to have the fourth segment open, as in *Karteroiulus*.

EXPLANATION OF ABBREVIATIONS USED

a=Apodematic gutter of Mound.
b=Hood of operculum.
C=Coxite.
d=Diverticulum of Vulvæ.
G=Gula.
H=Heart-shaped projection of operculum or synoperculum.
h=Horse-shoe plate or thickening of Mound.
i=Intermentum.
iv=Inner valve of Mound.
l=Ventral lobes of segments.
M=Mound of vulvæ.
O=Operculum of vulvæ.
o=oviduct.
ov=outer valve of Mound.
P2, *P3*=Second, third pairs of limbs.
p=Postmentum.
R=Stipes of gnathochilarium.
r=Ridge of Mound.
S=Sternite.
s=Shield of Vulvæ.
T=Telopodite of limbs.
T=Tracheal stalks.
u=Ventral dimples of segments.
v=Valves of Mound.
W=Vulvæ.
Y=Synoperculum of Vulvæ.

EXPLANATION OF PLATES.*

PLATE XIX.

Fig. 1. *Paeromopus lysiopetalinus.* Right mandibula, ventral aspect.
Fig. 2. *Paeromopus lysiopetalinus.* First pair of limbs, cephalic aspect.
Fig. 3. *Paeromopus lysiopetalinus.* Second pair of legs, vestibulum (*V*), and right vulvar invagination (*I*), caudal aspect. 1–5=Folds of aperture of vestibulum.
Fig. 4. *Paeromopus lysiopetalinus.* Left vulva, caudal aspect.
Fig. 5. *Paeromopus lysiopetalinus.* Left vulva, outer profile.
Fig. 6. *Paeromopus Chamberlini.* Cardo and stipe of left mandibula, ventral aspect.
Fig. 7. *Paeromopus Chamberlini.* Coxæ of second pair of legs of adult female, caudal aspect. *y*=paramesal projection of coxæ; 1–5= folds of aperture of vestibulum.
Fig. 8. *Paeromopus Chamberlini.* Right adult vulva, caudal aspect.
Fig. 9. *Paeromopus Chamberlini.* Mound and shield of right adult vulva, oblique caudal aspect.

PLATE XX.

Fig. 10. *Paraiulus tiganus.* Anterior end of adult female.
Fig. 11. *Paraiulus tiganus.* Ventral aspect of segments 1–3 of same.
Fig. 12. *Paraiulus tiganus.* Cephalic aspect of second segment (A) and ventral region of third (B). *n*=ventral ridge, and *u*=ventral dimple of 2d segment.
Fig. 13. *Paraiulus tiganus.* Cardo and stipe of left mandibula, ventral aspect.
Fig. 14. *Paraiulus tiganus.* Legs of second pair of adult female, cephalic aspect.
Fig. 15. *Paraiulus tiganus.* Mound of left adult vulva, outer aspect. *O*=membranous fold replacing the operculum.
Fig. 16. *Paraiulus tiganus.* Left vulva from above. *O*=membranous fold replacing the operculum.
Fig. 17. *Paraiulus tiganus.* Anterior truncation of left vulva, the opercular fold of which has been removed.
Fig. 18. *Paraiulus tiganus.* Left vulva of another adult female, outer aspect, showing individual variations in the diverticulum, *d*.

PLATE XXI.

Fig. 19. *Paraiulus tiganus.* Legs of second pair of larva and immature vulvæ, caudal aspect.
Fig. 20. *Paraiulus tiganus.* Base of legs of second pair of larva, cephalic aspect.
Fig. 21. *Paraiulus tiganus.* Immature vulvæ of Fig. 19, enlarged.
Fig. 22. *Paraiulus pennsylvanicus.* Anterior end of adult female.
Fig. 23. *Paraiulus pennsylvanicus.* Ventral aspect of segments 1–3 of same.
Fig. 24. *Paraiulus pennsylvanicus.* Cardo and stipe of left mandibula, ventral aspect.
Fig. 25. *Paraiulus pennsylvanicus.* Cephalic aspect of ventral region of second segment (A) and of third (B). *x*=membrane connecting the ventral margins of 3d segment and bearing the atrophied sternite of 2d legs, *P2*.
Fig. 26. *Paraiulus pennsylvanicus.* Right adult vulva, inner profile.
Fig. 27. *Paraiulus pennsylvanicus.* Right adult vulva, caudal aspect.
Fig. 28. *Paraiulus immaculatus.* Anterior end of adult female.
Fig. 29. *Paraiulus immaculatus.* Ventral aspect of segments 1–3 of same. *P2*=chitinised bridge with symmetrical thickenings homologous to sternite of second pair of legs.

*Camera drawings from the author.

PLATE XXII.

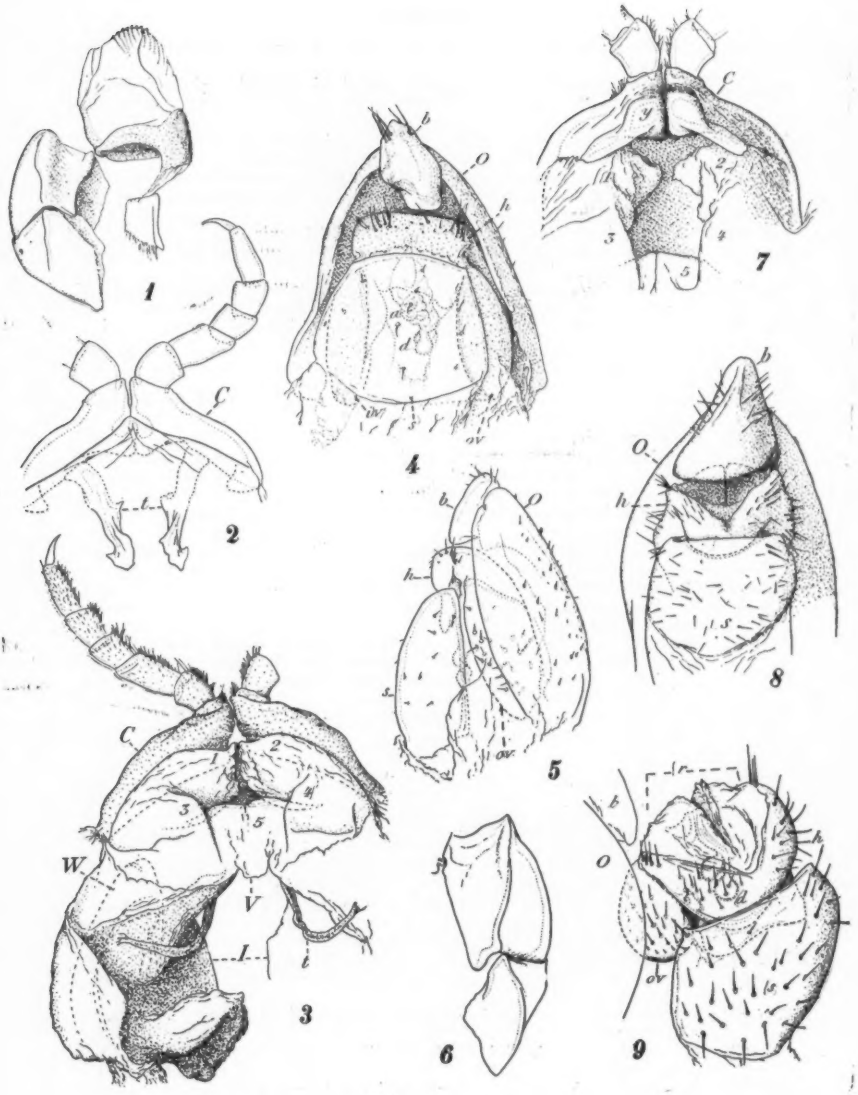
Fig. 30. *Paraiulus immaculatus.* Cardo and stipe of right mandibula, ventral aspect.
Fig. 31. *Paraiulus immaculatus.* Cephalic aspect of ventral region of second segment (A) and of third (B). *P2*=atrophied sternite of second legs.
Fig. 32. *Paraiulus immaculatus.* Adult vulvæ, caudal aspect.
Fig. 33. *Paraiulus immaculatus.* Right vulva, outer profile.
Fig. 34. *Paraiulus immaculatus.* Inner oblique view on the anterior truncation of left vulva, the operculum of which has been partly detached and turned aside.
Fig. 35. *Paraiulus impressus.* Anterior end of adult female.
Fig. 36. *Paraiulus impressus.* Ventral aspect of segments 1–3 of same. *S4*=sternite of 4th segment.
Fig. 37. *Paraiulus impressus.* Cephalic aspect of ventral region of second segment (A) and of fourth (B). *S4*=sternite of 4th segment.
Fig. 38. *Paraiulus impressus.* Gnathochilarium of adult female.

PLATE XXIII.

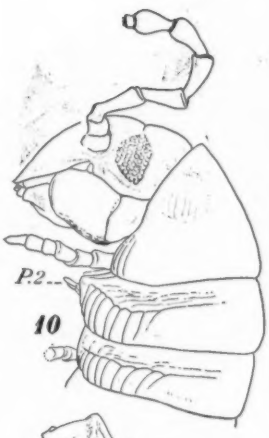
Fig. 39. *Paraiulus impressus.* Synoperculum and dwarfed legs of second pair, cephalic aspect.
Fig. 40. *Paraiulus impressus.* Both vulvæ, caudal aspect. The left mound is bent backwards and is seen from above. *c*=crest of the inner valve of the mound, and *w*=furrow of the outer valve. *e*=basal excavation of the synoperculum.
Fig. 41. *Paraiulus impressus.* Mound of left vulva, inner profile. *c*=crest of the inner valve.
Fig. 42. *Paraiulus impressus.* Base of legs of second pair of larva with immature vulvæ, caudal aspect.
Fig. 43. *Paraiulus venustus.* Anterior end of adult female.
Fig. 44. *Paraiulus venustus.* Ventral aspect of segments 1–3. *S4*=sternite of fourth segment.
Fig. 45. *Paraiulus venustus.* Cephalic aspect of ventral region of second segment (A) and of fourth (B). *S4*=sternite of fourth segment.
Fig. 46. *Paraiulus venustus.* Synoperculum and dwarfed legs of second pair, cephalic aspect. *O*=oviduct.
Fig. 47. *Paraiulus venustus.* Both vulvæ, caudal aspect. *x*=hardened area in the membrane of the vestibulum.

PLATE XXIV.

Fig. 48. *Paraiulus venustus.* Mound of the right vulva, outer profile.
Fig. 49. *Paraiulus venustus.* Mound of the right vulva, anterior truncation (cephalic aspect).
Fig. 50. *Paraiulus venustus.* Base of legs of second pair of larva with immature vulvæ, caudal aspect.
Fig. 51. *Paraiulus ellipticus.* Synoperculum and right mound (*M*), oblique caudal aspect. The left mound has been removed to show the plowshare-like process of the synoperculum, *x*.
Fig. 52. *Paraiulus ellipticus.* The left mound, outer profile.
Fig. 53. *Paeromopus Chamberlini.* Cardo and stipe of male left mandibula, ventral aspect.
Fig. 54. *Paeromopus Chamberlini.* Ventral aspect of segments 1–3 (under contraction).
Fig. 55. *Paeromopus Chamberlini.* Left leg of first pair of male. *A*=cephalic aspect; *B*=caudal aspect.
Fig. 56. *Paeromopus Chamberlini.* Right half of peltogonopods, cephalic aspect.
Fig. 57. *Paeromopus Chamberlini.* Left half of gonopods, cephalic aspect.



Henry W. Brolemann



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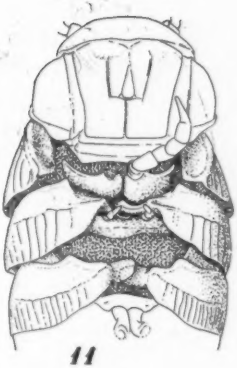

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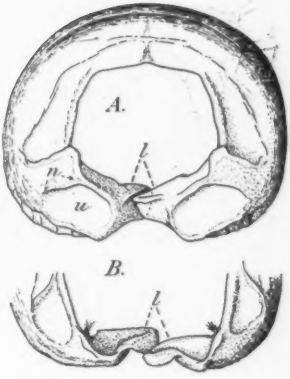

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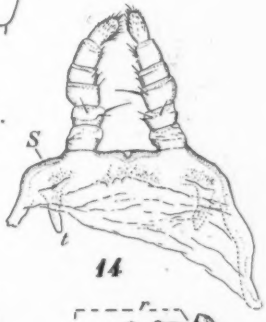

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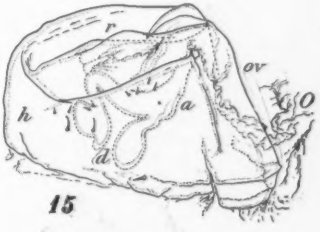

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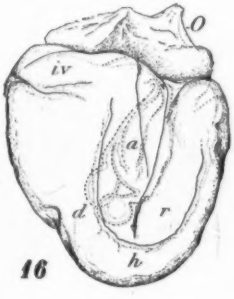

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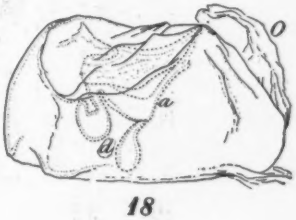

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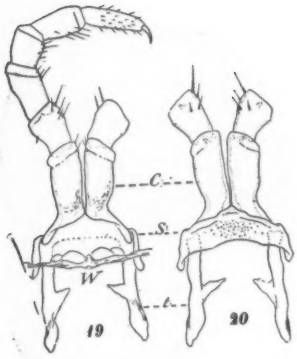

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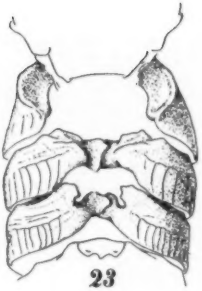

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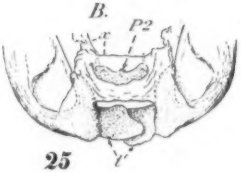

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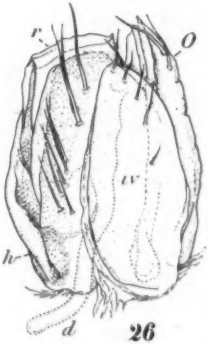

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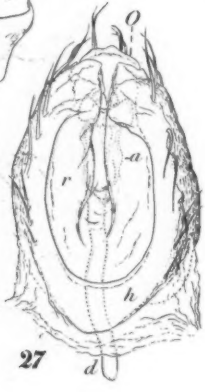

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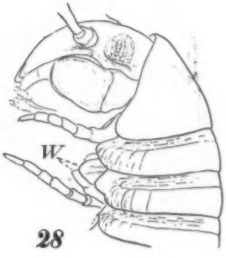

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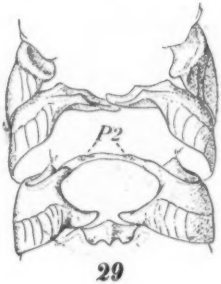

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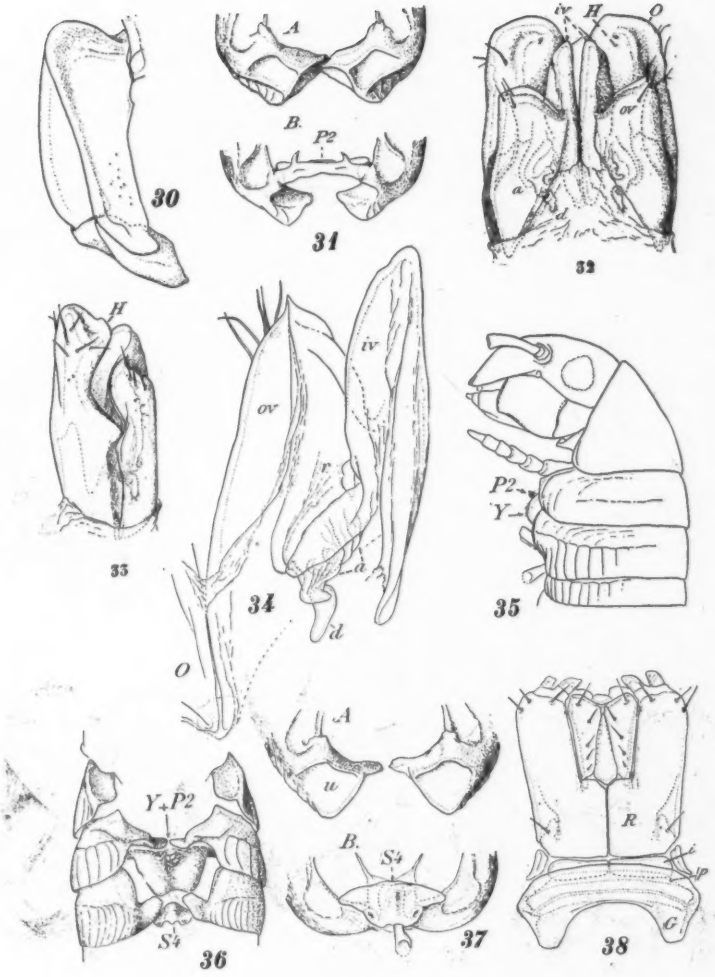

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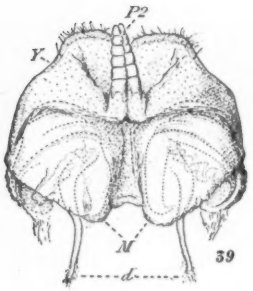

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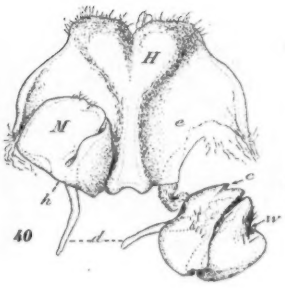

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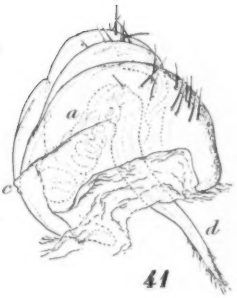

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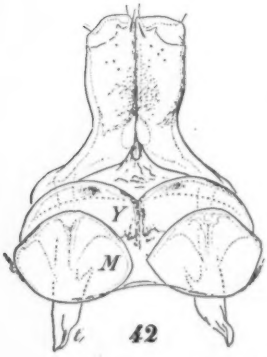

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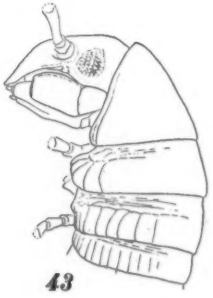
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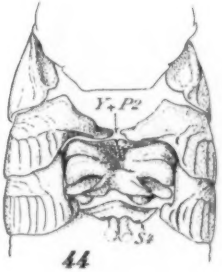

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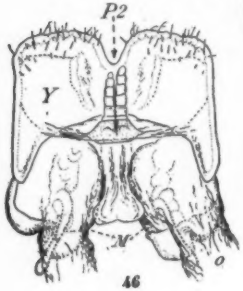

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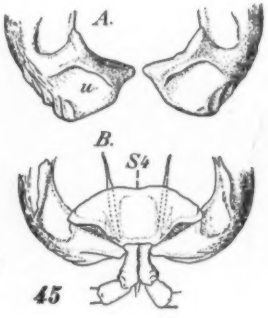

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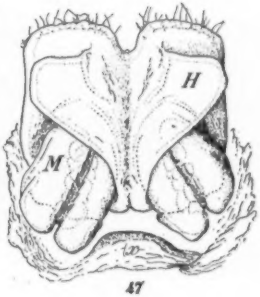

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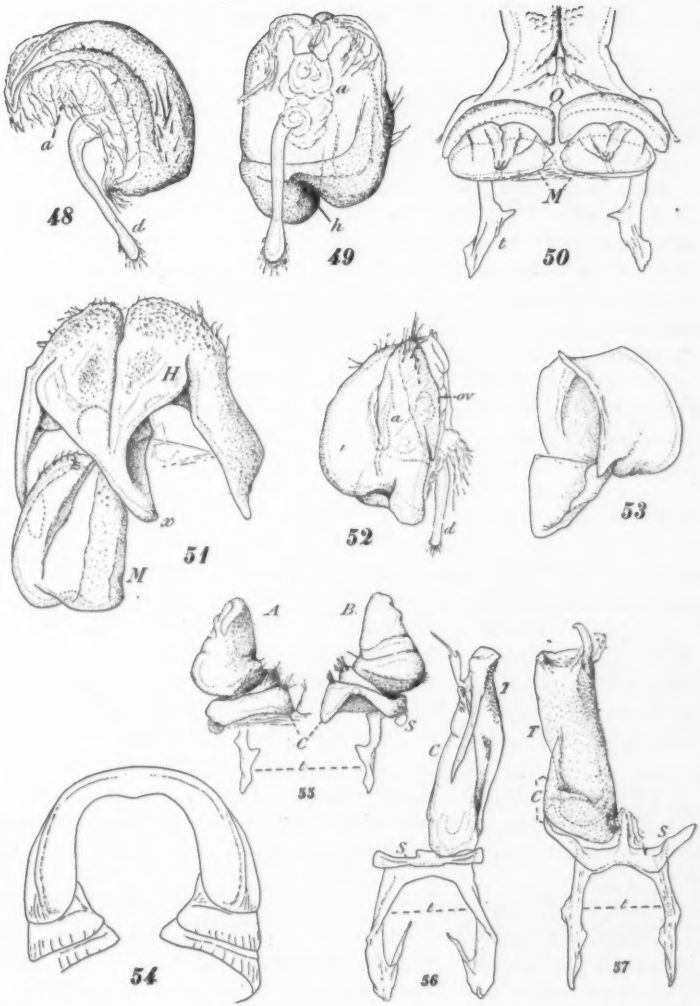

Henry W. Brolemann

HEAD AND MOUTH-PARTS OF MECOPTERA.

FAUSTINO Q. OTANES,
Bureau of Agriculture, Manila, Philippine Islands.

INTRODUCTION.

Our knowledge of the head and mouth-parts of the Mecoptera is fragmentary. Nothing comprehensive has been published dealing with the study of a collection of genera and species representative of the entire order. It was with the object of contributing to our knowledge of the morphology of the head and mouth-parts of the Mecoptera and to invite further investigation on the subject that this study was undertaken.

In order to make the work as comprehensive as possible, an attempt was made to study as many species as could be obtained, representing the different genera. Comstock, in his Manual for the Study of Insects, recognizes only one family of Mecoptera, the family Panorpidæ. In his paper on the Panorpidæ of America North of Mexico, Hine (1901) listed five genera, namely: *Merope*, *Boreus*, *Panorpodes*, *Panorpa* and *Bittacus*, dividing these into two groups, those with ocelli in one group and those without in the other. *Merope* and *Boreus* were placed in the first group and *Panorpodes*, *Panorpa* and *Bittacus* in the second. In a recent monograph of the Mecoptera, Esben-Petersen (1921) lists five families, namely: Bittacidæ, Boreidæ, Panorpidæ, Natiothaumidæ and Meropidæ. I have been able to study all of the genera listed by Hine. This comprises all of the families in Petersen's monograph with the exception of one, the family Natiothaumidæ, which like the family Meropidæ, includes only one species (*Natiothauma reedi* MacLachlan) and this is known to exist only in Chile and is very rare.

This study was carried on under the direction of Dr. Alex. D. MacGillivray, of the University of Illinois, and to him I am indebted for his constant encouragement and valuable suggestions and criticisms throughout the progress of this work. I am also indebted to Dr. MacGillivray for his efforts in securing

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specimens not obtainable locally, and I also wish to express my thanks to the following gentlemen who very kindly donated specimens: Dr. J. Chester Brodley, of Cornell University, for *Boreus nivoriundus;* Professor Arthur L. Lovett, of the Oregon Agricultural College, for *Panorpodes oregonensis;* Professor Franklin Sherman, Jr., of Raleigh, North Carolina, for *Panorpodes carolinensis;* and Mr. Nathan Banks, of the Museum of Comparative Zoology, for specimens of *Apterobittacus apterus* and *Merope tuber*. My thanks are also due to Professor S. A. Forbes and Dr. C. P. Alexander for specimens of *Bittacus strigosus* from the collections of the Illinois State Natural History Survey and lastly to Dr. J. W. Folsom, for specimens of *Boreus nivoriundus*, sent to him by Mr. Chas. Macnamara, of Arnprior, Ontario, Canada, and for certain references. I wish also to acknowledge the permission given by Dr. MacGillivray to use his terminology, which will be embodied in a book on insect morphology soon to be published.

METHODS.

The specimens of the head of the different species were treated for a few minutes with a five per cent solution of hot potassium hydroxide. Before being examined they were washed with distilled water and then transferred to 70% alcohol. All dissections and examination were made in alcohol under a binocular microscope. Parts with minute details were mounted temporatily on slides and studied under a compound microscope. An ocular eyepiece micrometer ruled in squares proved helpful in getting the proportions for the drawings.

FIXED PARTS OF THE HEAD.

The order Mecoptera is referred to by taxonomists as having the head prolonged into a trunk-like beak at the end of which are located the biting mouth-parts. An examination of the head of the various species studied shows that *Panorpodes* (Figs. 1, 17, 27) does not conform to this characterization of the order. It is very much orthopteran in form and is the most generalized of all the genera studied and has been taken as the type. *Panorpa* (Figs. 10, 24, 31) and *Boreus* (Figs. 14, 26, 32) are the only genera that possess a trunk-like beak and are the most specialized, *Boreus* being more so than *Panorpa*. *Bittacus* (Figs. 3, 19, 28), *Aptero-bittacus* (Figs. 5, 23, 29) and *Merope* (Figs. 7, 25, 30) are intermediate in form. It should be mentioned, however, that specialization is not monopolized by either *Boreus* or *Panorpa*. *Merope*, for example, is without ocelli and in this respect is more highly specialized than either *Boreus* or *Panorpa*.

The epicranial suture is undoubtedly the most important landmark on the head capsule of insects. In a discussion of the sclerites of the head, therefore, it is logical to begin with this suture. This suture is the inverted Y-shaped median stricture found in nymphs, larvæ and generalized adult insects. It marks the line of closure of the head during embryonic development. Originating at the occipital foramen, it extends along the dorso-meson for some distance and gives rise to two branches known as the epicranial arms. Each arm extends toward a compound eye in generalized adult insects and to the cephalic margin of the head in the case of larvæ. The stem of the epicranial suture, designated as the epicranial stem, is obsolete in all the species of Mecoptera studied. In a hypothetical type of the mecopterous head, the epicranial stem, as in generalized insects, originates from the occipital foramen and extends cephalad and ventrad along the meson and is interrupted at some point by the median ocellus. Emerging, still as a single suture from the ventral margin of the median ocellus, the epicranial stem extends ventrad of the antennariæ, where it divides into the epicranial arms, each arm extending laterad to a pretentorina and then ventrad, terminating in a precoila. In *Panorpodes* (Fig. 1), the epicranial arms (ea) are only partially present and the portion of each arm extending from a pretentorina (pn) to a precoila (pr) is obsolete. In *Bittacus* (Fig. 3), the entire epicranial arms are present and in this respect *Bittacus* is more generalized than *Panorpodes*. In *Apterobittacus* (Fig. 5), the transverse portion of the arms connecting the pretentorinæ has disappeared. In *Merope* (Fig. 7), the entire epicranial suture is obsolete. In *Panorpa* (Fig. 10), on the other hand, a portion of the arms is present and is, therefore, in this particular more generalized than *Merope*. In *Boreus* (Fig. 14), the same condition as in *Merope* obtains, the complete obsolescence of the epicranial suture.

The vertex (V, Figs. 1, 6, 14, 16, 19, 27, 28) extends from near the occipital foramen (of, Figs. 16, 19, 22) and ventrad to the sutures marking the boundary of the sclerites of the ventral portion of the head. In generalized insects, as the cockroach, the vertex is a paired sclerite, being divided along the meson by the epicranial stem. The vertex in the Mecoptera is a solid piece, not a paired sclerite, on account of the obsolescence of the epicranial stem. It bears, besides the compound eyes, the ocelli and the antennæ (a). Each lateral portion of the vertex is greatly prolonged ventrad in *Boreus* and *Panorpa*. There is a tooth-like lateral projection of the vertex in *Bittacus*, *Apterobittacus*, *Merope* and *Panorpodes* which is especially prominent in the species of the last named genus. This projection seems to be wanting in *Panorpa* and *Boreus*, but its homologue can be identified in these last two genera.

The fronto-clypeus (fc), formed by a fusion of the front and clypeus through the obsolescence of the fronto-clypeal suture, is, roughly speaking, subquadrate in *Panorpodes* (Fig. 1), *Bittacus* (Fig. 3), *Apterobittacus* (Fig. 5), and *Merope* (Fig. 6), and rectangular and greatly elongated in *Panorpa* (Fig. 10) and *Boreus* (Fig. 14). It is in general

setiferous and is fused with the labrum (l) in all the species studied. Its ventral extent, however, is marked by the position of the precoilæ (pr). In *Merope* and *Boreus*, the fronto-clypeus has completely merged with the vertex owing to the obsolescence of the entire epicranial suture; in *Bittacus*, the fronto-clypeus is wholly separated from the vertex by the epicranial arms, and in *Apterobittacus*, the fronto-clypeus is fused with the vertex along its dorsal margin owing to the obsolescence of the transverse portion of the epicranial arms, whereas in *Panorpodes* it is fused with the vertex along its lateral margins, brought about by the disappearance of the lateral parts of the epicranial arms.

There is a pair of membranous areas dorsad of the fronto-clypeus which connect the antennæ and the head (Fig. 1). These are the antacoriæ (an) and are located on the vertex in the Mecoptera. The size of the antacoriæ in the Mecoptera varies considerably, being smallest in *Bittacus* and most pronounced in *Panorpodes*. Surrounding each antacoria is a narrow, ring-like sclerite known as the antennaria (ar). There is a cuticular projection into the antacoria from the ventro-lateral portion of the antennaria, which is somewhat prominent in *Panorpa* (Fig. 31) and *Boreus* (Figs. 14, 32), designated as the antacoila (aa). Yuasa (1920) referred to the antacoila as being the "chitinized pin" in the cockroach, as described by Miall and Denny.

The compound eyes (ce), regarded as the appendages of the first, ocular or protocerebral segment are of considerable size in the Mecoptera and are especially prominent in *Bittacus* (Figs. 3, 28) in proportion to the size of the head. Viewed from the lateral aspect, the compound eyes are oval except in *Merope* (Figs. 7, 30), where they are oblong and emarginate on the cephalic margin, giving them a distinctly reniform shape, thus resembling the eyes of some Hymenoptera, as *Vespa maculata*. In *Bittacus* the eyes are slightly emarginate on the caudal margin, the reverse of *Merope*, giving the eyes also a kidney-shaped appearance. Each compound eye is surrounded by a narrow ring-like area, which is prolonged entad as an annular strongly chitinized plate. This area is called the oculata (ol) and was designated by Comstock and Kochi (1902) as an "ocular sclerite." These authors considered the oculata as the proximal segment of an ocular appendage. Crampton (1921), however, is not inclined to consider the oculata as a sclerite, stating that this area is not marked off by a true suture and objects to the consideration of the oculata by Comstock and Kochi as being the basal segment of an ocular appendage. Yuasa (1920) observed the oculata as being always present in all the species of Orthoptera which he studied and as well developed in the species having large compound eyes, as *Mantis religiosa* and *Melanoplus differentialis*. Peterson (1916) likewise recognized the oculata in Diptera and calls it the ocular sclerite, using the term proposed by Comstock and Kochi.

The normal number of ocelli is present in all of the genera studied, with the exception of *Merope*. They are more or less circular in outline and are most prominent in *Bittacus* and in *Apterobittacus*. They are located on the vertex as is true in all Entoptera. In *Bittacus* (Figs.

3, 28) and in *Apterobittacus* (Figs. 5, 29), the lateral ocelli (lo) are situated distinctly dorsad of the compound eyes, whereas they are mesad of the latter in the other genera where they are present. The ocelli are located on convex areas in *Panorpodes* (Fig. 1) and *Panorpa* (Fig. 10) and are close to each other in *Panorpa*. The median ocellus (mo) in all cases is slightly smaller than either of the lateral ocelli.

As stated previously, Hine (1901) divided the genera of the Panorpidæ into two groups, those with ocelli in one group and those without in another. *Merope* and *Boreus* were placed in the first group and *Bittacus*, *Panorpa* and *Panorpodes* in the other. In his monograph, as already referred to, Esben-Petersen (1921) divides the Mecoptera into five families, giving as one of the characteristics of the family Boreidæ to which *Boreus* belongs, the absence of ocelli. I found the normal number of ocelli present in the species of *Boreus* that I studied. The ocelli, however, were small and overshadowed by the black color and shiny appearance of the head, black with a bluish tinge. This is probably the reason why the ocelli in *Boreus* have been overlooked by previous workers. A few minutes' treatment of the head with a five per cent solution of potassium hydroxide will reveal the ocelli as circular, white opaque bodies. Each lateral ocellus is located near the dorso-mesal margin of a compound eye and the median ocellus between the antacoriæ (an). Judged from the location of the ocelli, *Boreus* is more specialized than any of the other genera.

There is a pair of depressions on the cephalic aspect of the head ventro-mesad of the compound eyes. These depressions are known as the pretentorinæ (pn), which mark the point of invagination of the pretentoria (pt, Figs. 37, 38, 39, 40). In *Panorpodes*, *Panorpa* and *Boreus*, the pretentorinæ are situated directly ventrad of the antacoriæ (an), while they are distant from the latter in *Bittacus*, *Apterobittacus* and *Merope;* they are, in these last three genera, near the ventro-mesal margin of the compound eyes and distinctly more so in *Bittacus* where they nearly touch the margin of the eyes.

In specialized insects, the pretentorinæ are not fixed in location. They may migrate away from the precoilæ (pr) but are usually located on or near the epicranial arms. In the Orthoptera, the pretentorinæ are located immediately dorsad of each precoilæ and are apparently distant from the epicranial arms. In the Mecoptera, they are isolated from the precoilæ and are markedly so in *Panorpa* and *Boreus*, owing to the great elongation of the fronto-clypeus.

The precoilæ (pr) in which the mandibles are articulated on the cephalic aspect are distinct in the Mecoptera. Each precoila is located at the ventro-lateral angle of the fronto-clypeus. In generalized insects, each precoila is situated at the caudo-lateral or dorso-lateral angle of the clypeus, depending upon the direction of the mouth-parts. In the honey-bee and other Hymenoptera, the precoilæ are similarly situated as in the Mecoptera. The clypeo-labral suture is obsolete in the Mecoptera studied.

The labrum (l) of *Panorpodes* (Fig. 1) is of considerable size, setiferous, narrower at tip, and each lateral margin is slightly emarginate.

The ventral margin is distinctly emarginate. That of *Bittacus* (Fig. 3) is elongated, narrows gradually ventrad and is slightly rounded at the apex. Its ventral half is fringed along the lateral margin with setæ, those toward the apex being rather prominent. The dorsal half of the lateral margin is thin and folded mesad (Fig. 52). The ventral portion of each lateral fold is also fringed with rather small setæ. The labrum of *Apterobittacus* (Fig. 5) is very similar to that of *Bittacus*. That of *Panorpa* (Fig. 10) is reduced on account of the great elongation of the fronto-clypeus. It is chordate in shape and its apical margin is emarginate. Each lateral margin is fringed with setæ, which are more prominent and are present in larger numbers than in *Bittacus*. *Boreus* (Fig. 14) has likewise a reduced labrum, which is rounded, fleshy and densely setiferous at the apical margin. The setæ of the distal margin are minute. The labrum of *Merope* (Fig. 7) has a bluntly pointed apex and its free margins are densely fringed with rather long setæ. The cephalic surface is also clothed with short setæ, an oblique row of such setæ being recognizable along each side of the meson.

In all the genera studied, the occipital foramen (of, Figs. 17, 19, 22), 24, 25, 26) is of considerable size and is divided into two parts by a strongly chitinized bridge designated as the corpotentorium (ct), or body of the tentorium. The dorsal or upper portion of the occipital foramen is larger than the ventral, with the exception of *Bittacus*, where they are almost of the same size. At each ventro-lateral margin of the dorsal portion of the occipital foramen is a strongly chitinized triangular projection known as an odontoidea (od), which serves as a point of articulation for a cervepisternum (ccs), a chitinized lateral sclerite of the cervix or neck which connects the head and the thorax. The membrane connecting the neck and the head is the cervicoria (cc). The odontoideæ are more prominent in *Panorpa* and *Panorpodes* than in *Bittacus*, *Apterobittacus* and *Boreus*. They can hardly be identified in *Merope*.

That part of the head adjacent to the occipital foramen and dorsad of the odontoideæ is known as the occiput (oc). In some insects, as in the grasshopper (*Melanoplus differentialis*) the occiput can be differentiated because of the partial presence of the occipital suture. It is divided along the meson by the epicranial stem. In all the mecopterous insects studied, the occiput is merged with the vertex owing to the obsolescence of the occipital suture.

In the Orthoptera, as in the grasshopper, there are two distinct sclerites, known as the postgenæ (pa), ventrad of the occiput, one on each side of the occipital foramen. In the same insect, there is a transverse suture which separates the occiput and a postgena. The suture in question is designated as the occipito-postgenal suture. In the mecopterous heads studied, the postgenæ are continuous with the vertex and occiput. In the absence of the occipito-postgenal suture, the odontoideæ may be used as landmarks in determining the point of division between the occiput and each postgena. In all the species treated in this paper, the postgenæ are of considerable size and in *Boreus* and *Panorpa*, they are prolonged ventrad as a narrow area.

At the apical margin of each postgena is a distinct acetabulum, a coila, known as a postcoila (ptl) in which the caudo-proximal portion of each mandible is articulated. The postgenæ in all the species of Mecoptera studied extend mesad and fuse on the meson, forming a bridge, known as the genaponta (gn), which limits the ventral extent of the occipital foramen. The genaponta in *Boreus* (Fig. 26) is a large area, whereas it is very narrow in the other genera.

In *Blatta* and other Orthoptera, the tentorium consists of the following parts: metatentoria, carpotentorium, pretentoria, laminatentorium and supratentoria. The tentorium in the Mecoptera (Figs. 37, 38, 39, 40) is not as well developed as in the Orthoptera. All of the typical parts of the tentorium mentioned above, except the laminatentorium, are present in the Mecoptera. The metatentoria (mt) support the lateral margins of the occipital foramen and are prolonged mesad, fusing into a strongly chitinized bridge known as the carpotentorium (ct) or body of the tentorium, and which, as has been stated previously, divides the occipital foramen into two portions. The points where the metatentoria are invaginated are the metatentorinæ (mn); as a rule they are not very distinct in the species of Mecoptera studied. The pretentoria (pt) or anterior arms of the tentorium connect the caudal and the cephalic aspects of the head. The places of invagination of the pretentoria are the pretentorinæ (pn), which have been described elsewhere. Arising from each pretentorium and connecting the latter with the ental portion of each lateral margin of an antennaria is a supratentorium (st). The supratentorium are best developed in *Bittacus* and *Apterobittacus* and are hardly distinguishable in *Panorpa* and *Panorpodes* where they are thread-like.

MOVABLE PARTS OF THE HEAD.

The antennæ are usually long, setiferous and multiarticulated in the Mecoptera. The antenna of *Boreus* (Fig. 35) is filiform and consists of twenty-three segments. Those of *Panorpodes* and *Panorpa*, like those of *Boreus*, are filiform and consist of a larger number of segments. *Bittacus* (Fig. 33) has a setaceous antenna consisting of about twenty segments. The antennæ of *Merope* (Fig. 34) are very different, moniliform, there being twenty-nine segments.

The mandibles of all the species studied are decussating. Those of *Panorpodes oregonensis* (Figs. 20, 21) are triangular and are provided with two distadentes (dd), the distal one being more prominent. The mesal margin is irregularly serrated. The mandibles of *Panorpodes carolenensis* (Figs. 15, 23) differ somewhat in shape and the distadentes are not as prominent. The mesal serration is more regular than that of *oregonensis*. Those of *Merope* (Figs. 9, 18), *Panorpa* (Figs. 11, 12), and *Boreus* (Figs. 4, 11) do not differ very much in shape from those of the two species of *Panorpodes*. Unlike those of *Panorpodes*, they are not serrated along the mesal margins. The mandibles of *Merope* and *Panorpa* are each provided with three distadentes, the lateral one being the most prominent and is especially well developed in *Merope*, and the mesal tooth the smallest. Hine (1901) gave as one of the characteristics

of the genus *Panorpa* the two-toothed condition of the mandibles. Examination of the mandibles of *Panorpa americana* and *Panorpa lugubris* shows that they are distinctly three-toothed. The mandibles of *Merope* are slightly emarginate at the middle of the mesal margin. Those of *Boreus* are six-toothed, the teeth decreasing in size toward the proximal portion of the mandible. *Bittacus* (Figs. 2, 8) has a distinctly different type of mandibles. They are greatly elongated, sword-shaped, and end in a prominent distadentis. There is also a rudimentary mesal tooth. At the meso-proximal portion of each mandible, there is present a conical projection, the function of which is not clear. Hine (1898), in his paper on the genus *Bittacus* failed to notice this, as may be judged from his descriptions and figures. The mandibles of *Apterobittacus* (Figs. 6, 16) are very much like those of *Bittacus*. In all the mandibles of the Mecoptera here considered, there is a prominent swelling on the caudo-proximal portion, a condyle, known as the postartis (ptc), which articulates in a distinct acetabulum of the postgena, the postcoila (ptl, Figs. 50, 52, 59). Each mandible articulates on its cephalic aspect to the precoila of the clypeus by means of another condyle known as the preartis (py). The tendons, to which the muscles of the head are attached, controlling the movement of the mandibles, are well developed. The lateral tendon, which is the smaller of the two, and to which the extensor muscles are attached, is known as the extensotendon (et), and the mesal tendon, to which the retractor muscles are attached, is called the rectotendon (rt).

The maxillæ are well developed in the Mecoptera. The maxillæ of *Panorpodes oregonensis* (Fig. 49) and *P. carolenesis* (Fig. 45) are very similar and they represent the most generalized condition of all the species examined. The maxillæ of *Boreus* are the most specialized owing to the fact that they are completely fused with the labium. The cardo (ca) in all the species is undivided and is strongly chitinized. In both species of *Panorpodes*, the cardo is triangular and with a few prominent setæ at ventro-lateral angle. It is also triangular in *Panorpa* and is provided with a few small setæ, whereas it is subquadrate in *Bittacus* (Fig. 41) and *Apterobittacus* (Fig. 44) and the setæ, as in *Panorpodes*, are prominent. The two cardines in *Merope* (Fig. 46) are club-like in outline and there is in each cardo a prominent projection on its ventro-mesal margin. The cardines in *Boreus* (Fig. 36) are fused and together with a part of the submentum form a somewhat elliptical plate. The stipes (s) is also strongly chitinized, generally club-shaped; in *Panorpodes*, *Bittacus*, *Apterobittacus* and *Panorpa* and with prominent setæ. As has been already stated, the maxillæ of *Boreus* are fused with the labium so that it is impossible to ascertain the mesal extent of the stipes. The stipes (s) in Merope (Figs. 46, 47) are broad and fused at the proximal end. There are two prominent lobes distad of the stipes in all the species. The outer or lateral lobe has been designated by other workers, among whom are Hine, Miyake and Crampton, as the galea and the inner or mesal lobe as the lacinia. In nearly all the species studied, the so-called lacinia is always the larger and the better developed of the two lobes, which is an anomaly,

considering the condition existing in other specialized insects. By virtue of the position of the lobes, these designations are logical, the part adjacent to the maxillary palpus is always the galea. In highly specialized insects, as the Diptera, the lacinia is in nearly all cases wanting and where it is present, as in *Simulium* and *Tabanus*, as Peterson has shown, it is greatly reduced and the question may be raised as to whether this is even the lacinia. In most Hymenoptera, the lacinia is greatly reduced and in certain cases, as MacGillivray has shown, the lacinia may be absent. He has also shown that in many species of Hymenoptera, as *Macroxyela infuscata*, *Dolerus unicolor*, *Ophion bilineatum* and *Vespa maculata*, the galea is divided into two lobes. This divided condition of the galea is what probably obtains in the Mecoptera; the two lobes represent subdivisions of the galea while the lacinia has completely disappeared. The lobes of the galea (gl) in *Panorpodes oregonensis* (Figs. 49, 58) are finger-like and setiferous and they are of about the same length. In *Panorpodes carolinensis* (Fig. 45) the outer lobe of the galea is distinctly shorter. In *Bittacus* (Figs. 41, 43) and *Apterobittacus* (Figs. 44, 53), the two lobes are greatly elongated, and the inner lobe is even longer than the stipes. In *Merope* (Figs. 46, 54), the two lobes have assumed the form of strongly chitinized triangular plates with dense brushes of rather long setæ. The mesal margins of the lobes are thick, somewhat fleshy and with numerous minute setæ. Figure 55 shows the lateral aspect of the two lobes in *Merope*. The brush presents a U-shaped appearance. In *Panorpa* (Figs. 42, 47) and *Boreus* (Figs. 36, 60), the lobes have been reduced in length owing to the greatly elongated stipes. In *Panorpa* they are of about the same size and are setiferous. In *Boreus* the inner lobe is fleshy, setiferous and provided with two rows of strong conical spines arranged diagonally at the proximal end. The outer lobe in *Boreus* is a triangular plate curved mesad.

The maxillary palpus (mp) is five-segmented and setiferous in all the species. The palpifer (pf) is chitinous in *Panorpa*, membranous in *Bittacus* and *Apterobittacus* and slightly so in *Boreus* and continuous with the first or proximal segment of the maxillary palpus. In *Panorpodes*, the palpifer cannot be differentiated; it is probably merged with the stipes. The maxillary palpi of *Boreus* differ markedly from those of the other species studied in that the segments increase in diameter distad, the distal segment being not only the broadest but also the longest.

The maxillæ in general are not articulated to the paracoila of the head by a parartis. They are merely connected with the head by means of the maxacoriæ (mc) which are distinct in all the species.

The labium (li) consists typically of the following parts in generalized insects: submentum, mentum, and ligula, the latter of which consists of the stipulæ, glossæ, paraglossæ, palpigers and labial palpi. The mentum is in most cases small, completely fused with the stipulæ and cannot be identified as a separate sclerite. In both species of *Panorpodes* (Figs. 45, 49), the area between the stipes and cardines is entirely membranous. This area comprises the submentum (sm)

and the labicoriæ (lc), the membranes which connect the maxillæ and the labium in all generalized insects where the submentum is a distinct sclerite. In *Panorpa americana* (Fig. 48), the submentum is membranous except the ventral portion, which is distinctly chitinized. This chitinized portion of the submentum was designated as the mentum by Crampton (1921) in his figure for *Panorpa lugubris*, not indicating, however, the submentum. I have also examined specimens of the labium, as well as other parts of the head, of *Panorpa lugubris* and have not found marked morphological differences between it and that of *Panorpa americana*. The labicoriæ of *Panorpa americana*, as in *Panorpodes*, are continuous with the submentum. In *Bittacus* (Fig. 19) and *Apterobittacus* (Fig. 44), the chitinized portion of the submentum (sm) is an elongate area, vase-like in outline and bears long, prominent setæ. The ventral portion of this area was likewise designated by Crampton (1921) in his figure for *Bittacus* (species not indicated), as the mentum, labeling the dorsal portion of it as the submentum. Hine (1898) in his figure of the labium of *Bittacus strigosus*, showed the area between the stipes and cardines, considered as the submentum and labicoria in this paper, as if it were wholly setiferous and failed to indicate the chitinized area, which is rather distinct. Hine further considered the ligula as being absent. In *Merope* (Fig. 46), the submentum (sm) and labicoriæ have become strongly chitinized, except the portion between the cardines. In *Boreus* (Fig. 36), the area has become completely chitinized and fused with the stipes. We have thus in the Mecoptera a modification of this area from a wholly membranous to a wholly chitinized condition and also a condition where the maxillæ are distinctly differentiated from the labium in one case and another where they are distinctly continuous with it.

There is a subquadrate area distad or ventrad of the submentum which consists of the fused stipulæ, palpigers, glossæ and paraglossæ. This area is here designated as the mecaglossa, because it is typical of the Mecoptera. The palpigers (pp) are represented in all the figures as occupying the distal portion of the mecaglossa and include the somewhat membranous areas at the proximal ends of the labial palpi. Crampton (1921) calls the mecaglossa in *Panorpa lugubris* the palpigers, although, he says, they may represent the basal segments of the labial palpi. In his figure of the labium of the same species, he shows a distinct suture between what he calls the palpigers. Besides *Panorpa americana*, I have also examined numerous specimens of the labium of *Panorpa lugubris* and I was unable to find a suture dividing what he terms the palpigers. What appears to be a suture is a thickening formed by the fusion of the tendons which control the movement of the labial palpi. There is a depression along the region he indicates, but it is such a broad depression that it can not be called a suture.

The mecaglossa is very different from the stipulæ, glossæ and paraglossæ of generalized insects where there is a palpiger attached to the lateral margin of each stipula. It is a greatly reduced area in the Mecoptera and the palpigers are distal in position. The obsolescence of the sutures separating the glossæ and paraglossæ from the stipulæ and

the marked reduction of the mecaglossa as a whole has misled most authors in considering the mecaglossa as the palpigers.

The labial palpus (lp) in all of the species is two-segmented. The first segment in most cases is broad and fleshy, especially in the case of *Panorpa* (Fig. 48). At the base of the first segment of the labial palpus of *Panorpa* there is a chitinized plate which Miyake called the "basal piece." In his figure of *Bittacus*, and it is unfortunate that he did not indicate the species, Crampton (1921) shows, besides emphasizing it in the text, that each labial palpus is three-segmented. He makes some use of this condition in attempting to establish close relationship between the Neuroptera, Diptera and the Mecoptera. I have examined many specimens of the labium of *Bittacus strigosus* and found only two segments in the labial palpus. The distal segment is never divided as far as observed. Miyake figures two segments in *Bittacus nipponicus* and states for the Japanese Mecoptera as a whole: "The labial palpus is very conspicuous, consisting of two joints." Can it be that within the same genus the number of segments in the labial palpus varies to this extent or has Crampton made an error? Even in widely different genera of Orthoptera, the number of segments in the labial palpus is constant; it is always three. My specimen of *Apterobittacus* also shows a two-segmented condition of the labial palpus and this was formerly placed within the genus *Bittacus*.

The pharynx is defined as the portion of the alimentary canal extending from the occipital foramen to the mouth, the mouth being the opening surrounded by the mouth-parts. The pharynx has two main parts, a cephalic or ventral portion, depending on the position of the head, called the prepharynx, and a caudal or dorsal portion called the postpharynx (pox) which is always tubular. The prepharynx includes the epipharynx, hypopharynx and other parts. The size of the epipharynx (ex) varies with the size of the labrum, which in turn varies with the size and shape of the head. It is greatly reduced in *Panorpa* (Fig. 61) and *Boreus*, owing to the greatly elongated frontoclypeus. The epipharynx (ex) in general has minute circular areas, which are most numerous in *Panorpodes* (Fig. 50). These circular areas are probably portions of taste organs, which Packard (1889) designated as the taste cups. They are also found on the labium and the maxillæ. In *Panorpa* (Fig. 61), there is an oblique row of minute setæ on each side of the meson and along each side of this row of setæ there is a group of the circular areas that have been referred to previously. The epipharynx in *Merope* (Fig. 59) is densely clothed with very minute setæ.

The hypopharynx (hx) in the Mecoptera is well developed, except in *Boreus*, where it is somewhat reduced. In general it is tongue-like in appearance and is setiferous. At the base of the hypopharynx, where it joins the labium, is located the opening of the salivary duct, called the salivos (so). The salivary duct can be easily identified in many of the species. It is very well developed in *Apterobittacus* (Fig. 53) and its striated condition is very apparent.

SUMMARY.

Of all the genera represented in this study, namely: *Panorpodes*, *Bittacus*, *Apterobittacus*, *Merope*, *Panorpa* and *Boreus*, the first one, *Panorpodes*, is the most generalized. The head is orthopteran in form and does not have a trunk-like beak. *Boreus* and *Panorpa* are the most specialized, *Boreus* being markedly more so than *Panorpa*. These genera are the only two that possess a distinctly trunk-like beak.

The order Mecoptera is commonly characterized as having the head prolonged into a trunk-like beak at the end of which are located the biting mouth-parts. This characterization of the order is inaccurate and somewhat misleading. The term "trunk-like beak" does not fit most of the genera and moreover, the only mouth-parts located at the end of the beak are the mandibles.

Certain sclerites of the head and mouth-parts are given new interpretations. The portions of the labium which have been regarded as the palpigers by some authors are designated as the mecaglossa, because it is typical of the Mecoptera. It comprises the fused stipulæ, palpigers, glossæ and paraglossæ. The labial palpus is always two-segmented. The two lobes, commonly regarded as a galea and a lacinia, are here considered as subdivisions of the galea.

The American species of Mecoptera offer no evidence confirmatory of the opinion of Crampton and Tillyard that the glossæ and paraglossæ of Peterson in the Diptera are homologous with the labial palpi.

The normal number of ocelli present is three. They are ordinarily large and subadjacent. The ocelli are wanting in *Merope*. Authors hitherto have described the ocelli as wanting in *Boreus*. I have found three small, distant inconspicuous ocelli in this genus.

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LIST OF ABBREVIATIONS.

a—antenna.
aa—antacolla.
af—antafossa.
an—antacoria.
ar—antennaria.
ca—cardo.
cc—cervicoria.
ccs—cervepisternum.
ce—compound eye.
ct—corpotentorium.
dd—distadentes.
ea—epicranial arm.
et—extensotendon.
ex—epipharynx.
fc—fronto-clypeus.
fl—flagellum.
hx—hypopharynx.
gl—galea.
gn—genaponta.
l—labrum.
lc—labicoria.
li—labium.
lo—lateral ocellus.
lp—labial palpus.
mc—maxacoria.
md—mandible.
mg—mecaglossa.
mn—metatentorina.
mo—median ocellus.
mp—maxillary palpus.
mt—metatentorium.
oc—occiput.
od—odontoidea.
of—occipital foramen.
ol—oculata.
p—pedicel.
pa—postgena.
pf—palpifer.
pn—pretentorina.
pox—postpharynx.
pp—palpiger.
pr—precoila.
pt—pretentorium.
ptc—postartis.
ptl—postcoila.
py—preartis.
rt—rectotendon.
s—stipes.
sc—scape.
sld—salivary duct.
sm—submentum.
so—salivos.
st—supratentorium.
v—vertex.

EXPLANATION OF PLATES.

PLATE XXV.

Fig. 1. *Panorpodes oregonensis*, cephalic aspect of head.
Fig. 2. *Bittacus strigosus*, cephalic aspect of sinistral mandible.
Fig. 3. *Bittacus strigosus*, cephalic aspect of head.
Fig. 4. *Boreus nivoriundus*, caudal aspect of sinistral mandible.
Fig. 5. *Apterobittacus apterus*, cephalic aspect of head.
Fig. 6. *Apterobittacus apterus*, cephalic aspect of sinistral mandible.
Fig. 7. *Merope tuber*, cephalic aspect of head.
Fig. 8. *Bittacus strigosus*, caudal aspect of sinistral mandible.
Fig. 9. *Merope tuber*, cephalic aspect of sinistral mandible.

Fig. 10. *Panorpa americana*, cephalic aspect of head.
Fig. 11. *Boreus nivoriundus*, cephalic aspect of sinistral mandible.
Fig. 12. *Panorpa americana*, caudal aspect of sinistral mandible.
Fig. 13. *Panorpa americana*, cephalic aspect of sinistral mandible.
Fig. 14. *Boreus nivoriundus*, cephalic aspect of head.
Fig. 15. *Panorpodes carolinensis*, cephalic aspect of sinistral mandible.
Fig. 16. *Apterobittacus apterus*, caudal aspect of sinistral mandible.
Fig. 17. *Panorpodes oregonensis*, caudal aspect of head.
Fig. 18. *Merope tuber*, caudal aspect of sinistral mandible.
Fig. 19. *Bittacus strigosus*, caudal aspect of head.
Fig. 20. *Panorpodes oregonensis*, caudal aspect of sinistral mandible.
Fig. 21. *Panorpodes oregonensis*, cephalic aspect of sinistral mandible.
Fig. 22. *Apterobittacus apterus*, caudal aspect of head.
Fig. 23. *Panorpodes carolinensis*, caudal aspect of sinistral mandible.

PLATE XXVI.

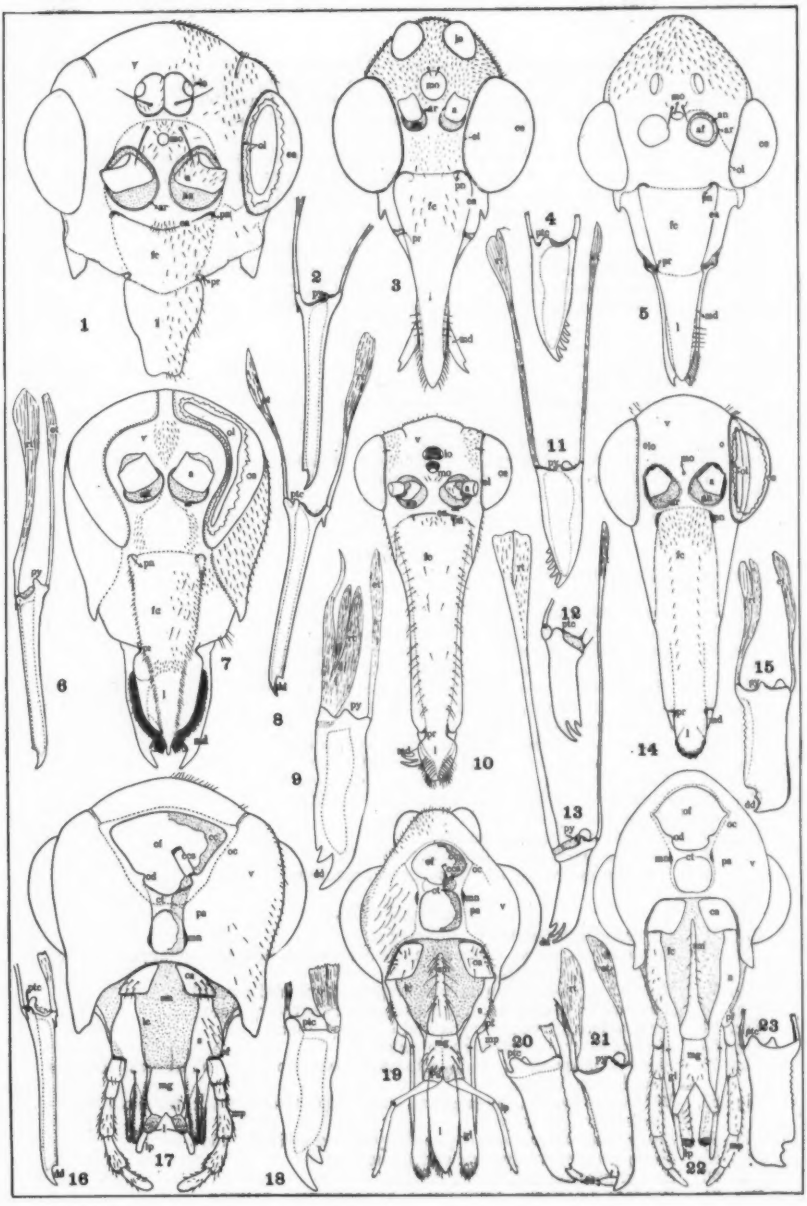
Fig. 24. *Panorpa americana*, caudal aspect of head.
Fig. 25. *Merope tuber*, caudal aspect of head.
Fig. 26. *Boreus nivoriundus*, caudal aspect of head.
Fig. 27. *Panorpodes oregonensis*, lateral aspect of head.
Fig. 28. *Bittacus strigosus*, lateral aspect of head.
Fig. 29. *Apterobittacus apterus*, lateral aspect of head.
Fig. 30. *Merope tuber*, lateral aspect of head.
Fig. 31. *Panorpa americana*, lateral aspect of head.
Fig. 32. *Boreus nivoriundus*, lateral aspect of head.

PLATE XXVII.

Fig. 33. *Bittacus strigosus*, antenna
Fig. 34. *Merope tuber*, antenna.
Fig. 35. *Boreus nivoriundus*, antenna.
Fig. 36. *Boreus nivoriundus*, labium and maxillæ.
Fig. 37. *Panorpodes oregonensis*, ental portion of tentorium.
Fig. 38. *Panorpodes oregonensis*, lateral view of tentorium.
Fig. 39. *Panorpodes oregonensis*, caudal aspect of tentorium.
Fig. 40. *Bittacus strigosus*, lateral view of tentorium.
Fig. 41. *Bittacus strigosus*, maxilla.
Fig. 42. *Panorpa americana*, cephalic aspect of galea.
Fig. 43. *Bittacus strigosus*, cephalic aspect of galea.
Fig. 44. *Apterobittacus apterus*, labium and maxillæ.
Fig. 45. *Panorpodes carolinensis*, labium and maxillæ.
Fig. 46. *Merope tuber*, labium and maxillæ.
Fig. 47. *Panorpa americana*, maxilla.
Fig. 48. *Panorpa americana*, labium and maxillæ.
Fig. 49. *Panorpodes oregonensis*, labium and maxillæ.

PLATE XXVIII.

Fig. 50. *Panorpodes oregonensis*, epipharynx.
Fig. 51. *Panorpa americana*, diagrammatic section to show hypopharynx, salivos and salivary duct.
Fig. 52. *Bittacus strigosus*, epipharynx, hypopharynx and mandible.
Fig. 53. *Apterobittacus apterus*, hypopharynx and salivary duct.
Fig. 54. *Merope tuber*, hypopharynx and salivary duct.
Fig. 55. *Merope tuber*, lateral view of galea.
Fig. 56. *Panorpa americana*, caudal aspect of head, to show mandibles, tendons and postpharynx.
Fig. 57. *Bittacus strigosus*, mecaglossa and palpi folded back to show hypopharynx and salivos.
Fig. 58. *Panorpodes oregonensis*, hypopharynx and salivary duct.
Fig. 59. *Merope tuber*, epipharynx and mandible.
Fig. 60. *Boreus nivoriundus*, hypopharynx.
Fig. 61. *Panorpa americana*, epipharynx, hypopharynx, salivos.



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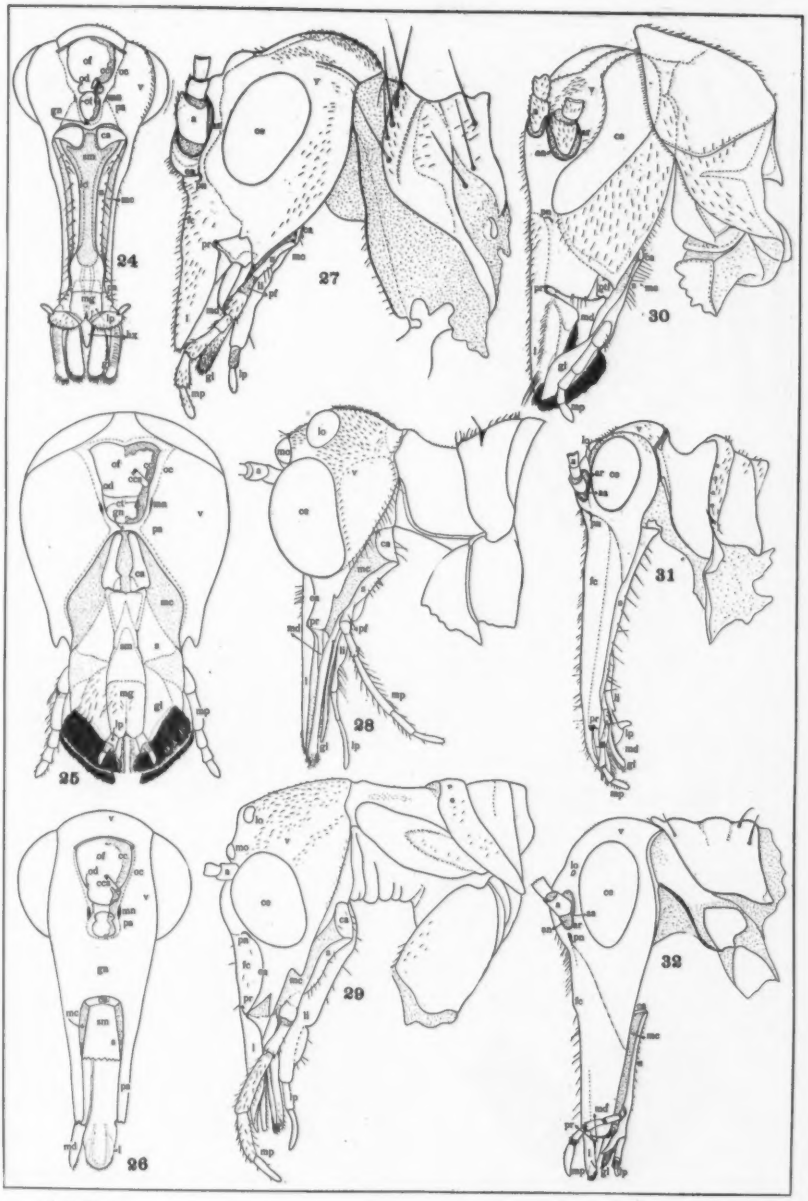

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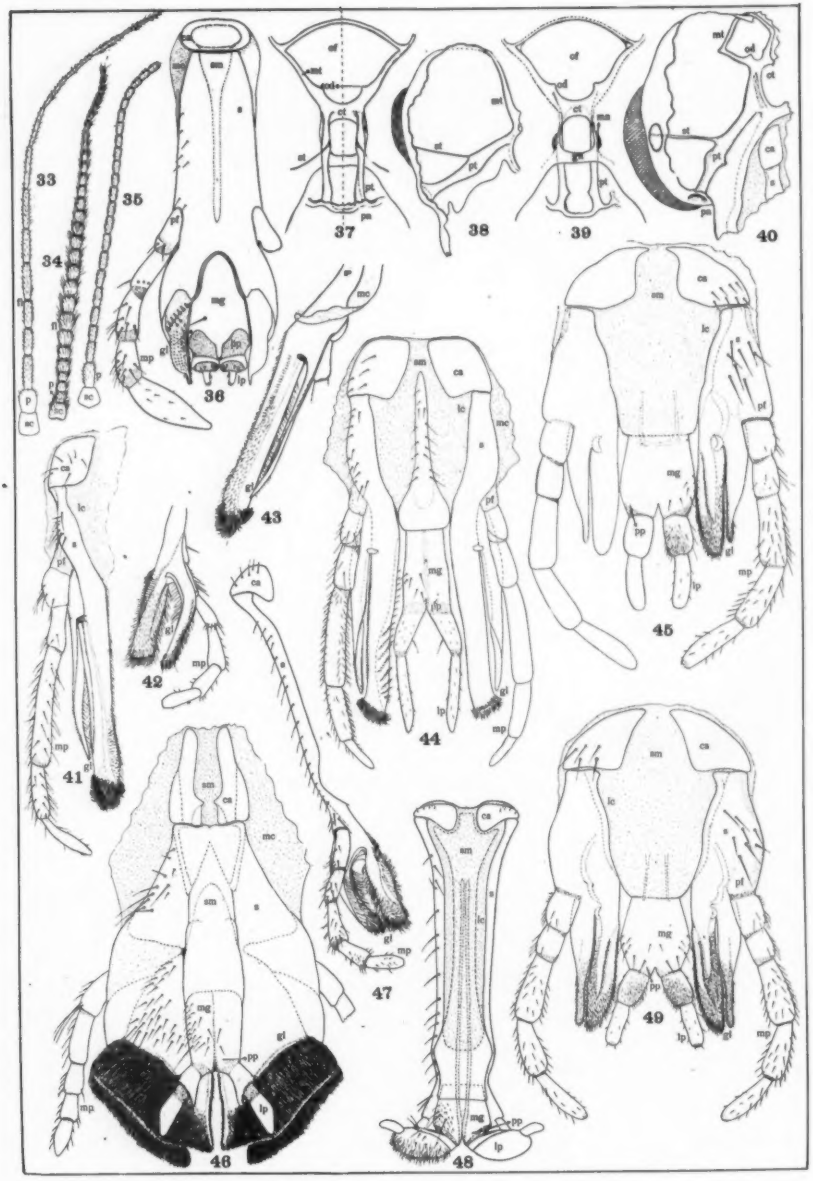

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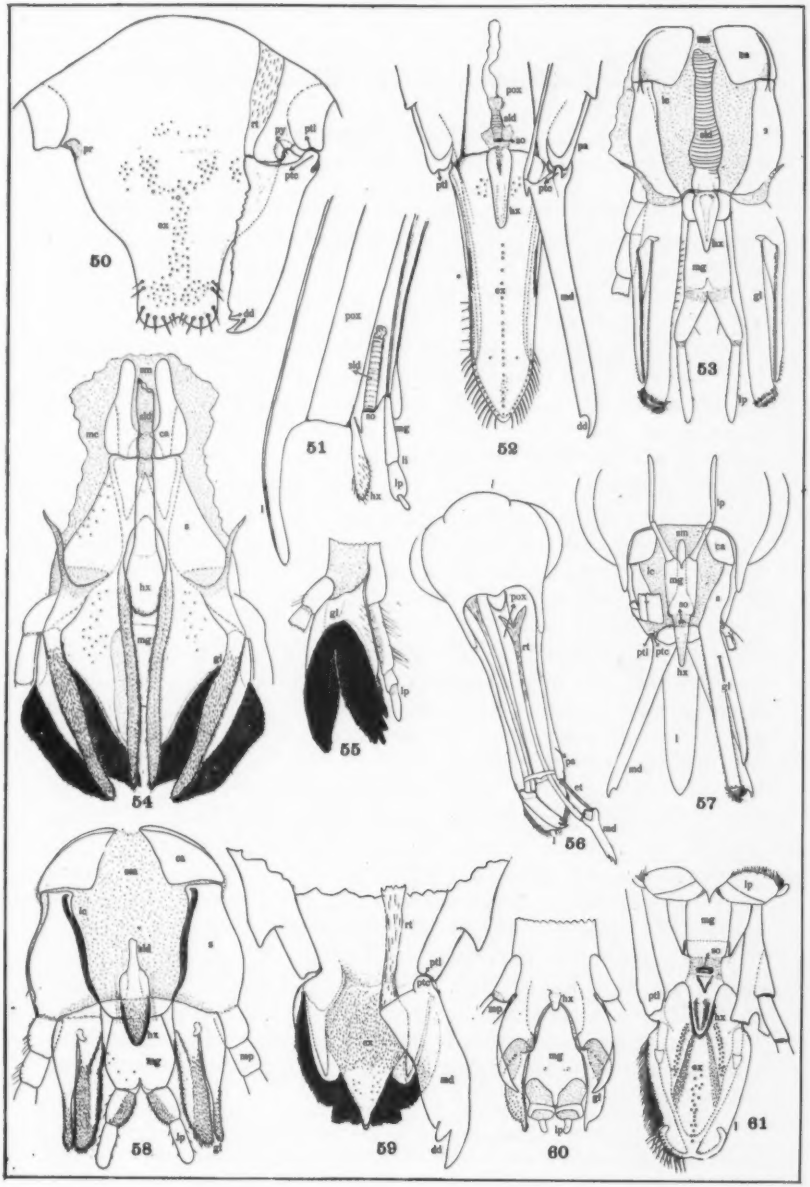

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THE WING-VENATION OF THE COLEOPTERA.*

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In the course of the last two generations, since the first attempts by Adolph (Nova Acta der Leop.-Carol. deutschen Akad. d. Naturf. 41(2), 213, 1880.) and Redtenbacher (Ann. d. k. k. naturhist. Hofmuseums I, 153, 1886) the comparative study of the wing-veins of the various groups of insects, supplemented by that of their larval tracheæ, has shown that all insect wings have a venation based on a common plan, whose modifications in the various orders are for the most part, well understood. In the Coleoptera, alone, of the larger orders, there is nothing approaching agreement in interpretation, for several reasons. In the first place the venation is sufficiently unique, and complicated, to make such a superficial study as brought even Adolph and Redtenbacher close to the truth in the Lepidoptera, for instance, almost completely futile. The complicated foldings also interrupt the veins and cause distortions in their courses. Further, the first forms studied for their pupal tracheation were specialized Cerambycidæ, a family in which the tracheation is degenerate and no longer fully corresponds to the veins. Several workers, notably Kempers (Tijd. voor Entom. 42 to 45) and Kolbe (Archiv fur Naturges. 67: Beiheft 89, 1901) have been thrown off by Adolph's or Woodworth's theories of an alternate system of convex and concave veins, which in the manner applied by them, is deceptive in the higher orders. More recently d'Orchymont has proposed a more carefully studied scheme, but his also ignores the evidence of the tracheation, and to me seems only half correct. Kühne's study of the tracheation (Zeits. wiss. Zool. 112: 692) alone has resulted in essentially the same conclusions which are expanded below. His paper is somewhat diagrammatically illustrated and appears to have been largely ignored by other workers; but I have veritfied his main conclusions, the differences between our results being mainly a matter of interpretation.

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In the present paper I shall try to identify the main veins of the Coleopterous wing with those recognized in other orders, and will suggest a tentative scheme of their branching. The main identifications, though differing from the several schemes which now hold the field, are supported by a convergence of evidence from the tracheation and basal sclerites, as well as by the character of the veins themselves.

In interpreting the tracheation my first assumption has been that each trachea which is separate in the most generalized form available, represents a single main vein, and that together all the veins are accounted for. In a single particular this assumption has been slightly modified—the identification of the first anal stem, as discussed below.

To take up the main veins in order:

Costa.—In all the orders of insects the costal vein lies along the costal edge of the wing, or is preceded only by a membranous strip, and runs far basad, forming a hook-like articulation with the body. It contains a weak trachea or none. In the Coleoptera studied the base of the costal edge is occupied by a vein, which in Calosoma contains a weak trachea. This is certainly *costa*. In a few forms (Silpha, Fig. 24, and Buprestidæ, for instance) there is a little membrane in front of it, but never another vein.

Subcosta.—In all the known orders of insects subcosta is immediately recognizable as a concave vein, that is, it lies at the foot of a trough in the surface of the wing, and its cavity is mainly below the level of the wing-membrane. The second vein from the costal edge in all the Coleoptera is so formed, and may be safely labelled *subcosta*. It contains a strong trachea in all the forms studied (the one labeled "C" by Comstock and Needham, who overlooked costa).

Radius.—The third vein of the wing is strongly convex, and forms the principal articulation with the thorax, together, that is, with the second axillary sclerite, from which it rises. Its trachea is always strong, and rises from the anterior tracheal trunk (Chapman, in Comstock's "Wings of Insects") running in front of the wing-process in close proximity to C and Sc. In the Coleoptera the third of the three closely crowded veins at the costal margin of the wing articulates in the proper manner, and contains the most posterior of the tracheæ arising from the anterior trunk, in every form studied, from Cicindela to the Cerambycidæ. It then is *radius*.

Media.—With media a more serious problem arises. Media is highly unstable in the various orders of insects and may associate itself as a branch with either radius or cubitus. In the Coleoptera whose tracheation is most complete, however, (Calosoma, Fig. 2, Dytiscus, Fig. 5, for instance, and some specimens of Tenebrio, Fig. 6), there is an independent trachea that can only be media. In Calosoma

and Tenebrio, at least, it arises from the posterior tracheal trunk, as in the majority of specialized insects. The corresponding vein is always weak, fading out at the base, and the trachea shows a strong tendency to weaken, and to lose its terminal portion to the neighboring tracheæ. In Tenebrio it is individually unstable, in some specimens independent, in others arising from the base of Cu. In many forms its basal part is a mere rudiment (labeled R in Comstock's "Wings of Insects," Figs. 309, 310), while its outer part has switched its connection to branches running up from Cu, or more rarely down from R. The weakness of this vein and trachea would characterize it as M, even were there not the further evidence of its position immediately following the unmistakable Sc and R. It is a "concave" vein, like M in the Lepidoptera and Neuroptera, and as in them it has no direct connection to the basal sclerites.

In all those Coleoptera whose basal venation is sufficiently spaced out, there is an arculus-like bar running across from the base of radius to Cu. This evidently represents an *anterior* arculus, being a short sector of vein M (Fig. 6), whose extreme base has fused with R, while it anastomoses immediately after, with Cu. In a few cases, where the medial trachea is independent, it can be plainly seen, passing from the radial to the medial vein-cavity through this bar.

Cubitus.—Cubitus is a strong convex vein. Here is perhaps the best opportunity for disagreement in interpretation. My identification is based, *first*, on the position and independence of the trachea in the Adephaga, which have the fullest tracheation, and in some specimens at least, of various Serricorns; *second*, on its basal connection with the axillary sclerite (though d'Orchymont considers this connection secondary, a result of fusion with the vein I interpret as 1st A); *third*, on the fact that the next vein (1st A) arises out of it near its base, just as the vein so called does in the Lepidoptera, and several other orders, and as the homologous vein (commonly called Cu_2) does in the Neuroptera and Trichoptera.

First anal.—The difficulty as to this vein is rather one of nomenclature than of homology, save only in the Phytophaga and Lamellicorns. In the most primitive orders there is an independent vein lying between Cu and the anal fan (1st A of Comstock's figures 116 to 124). This is in early forms fluctuating in position, and possibly even duplicated in a few cases (Comstock, Fig. 117, hind wing); attaching itself either to Cu or to the anal fan; but in almost all cases lies close beside the anal furrow. In the holometabolous orders it has become definitely associated with the cubital stem and appears like a branch of cubitus near the base. For this reason it is commonly treated as a branch of Cu in certain orders (e. g., the Neuroptera) and has been illogically labeled Cu_2. Of course if counted at all with the cubitals it would be Cu_3, as it would be the third branch of that stem. In other orders (as the Lepidoptera and Diptera) the connection with Cu is inconspicuous, either on account of a secondary splitting back, or through atrophy of the vein itself (butterflies); and the vein has been counted as independent, the true vein Cu_2 being correctly so labeled.

In the Coleoptera, save in the Phytophaga and some Lamellicorns, there is a trachea which splits off from Cu near its base, then frequently runs obliquely through the membrane, and enters a vein in the outer part of the wing, running with it to the margin (Figs. 3, 5, 6). The concave anal furrow lies close below this trachea. In Cupes (Figs. 4, 12) the whole is represented by a vein, and meets all the qualifications of 1st A (that is, Cu_3). In higher phytophaga at least, this trachea is completely absent, as shown by a Comparison of Comstock's figures 308 to 310, with mine of Tenebrio (Figs. 6, 43); and the corresponding vein of the imago is also absent.

Second and following anals.—There remain two branched tracheæ, and a third which is also bifurcated in the Adephaga, but more commonly simple. These may be numbered in order: 2d A, 3d A and 4th A. They doubtless represent the anal fan of lower orders, and also the second and third anals, and supporting vein of the jugum in, the Lepidoptera. The first of these is 3-branched at least, as shown plainly in the Buprestidæ (Figs. 6a, 34); but the anterior branch, both trachea and vein, is lost in many families, including all the Adephaga, Palpicornia and Heteromera; and the posterior branch, save in the Elaters, Lampyrids, and some Buprestidæ and Dermestidæ, fuses at the apex with the anterior branch of 3d A.

In this discussion the anals are treated as four in number on account of the tracheal arrangement, and seem to be homologous with the three recognized anals and the jugal brace of the Lepidoptera; but the condition in the base of the wing is complex, and comparison with Chauliodes (Fig. 71: a form which shows the same number of terminal anal branches) suggests strongly that the second may be a fusion of an original second and third anal; and that the vein here considered a cross-vein between 2d A and 3d A may really be a fourth branch of 2d A; in several forms it has a trachea.

The permanent cross-veins.—Certain cross-veins are so constant in higher insects as to become a part of the hypothetical plan. These are the *humeral*, the *arculus*, and a series near the middle of the wing (known as discocellulars in the Lepidoptera). The humeral cross vein shows plainly in several Coleoptera as a short fusion of C and Sc, which are everywhere closely parallel. Arculus is plain enough, especially in the Serricorns and Heteromera, (Figs. 65 and 66 for instance), and has already been discussed as a sector of media. The discocellulars, if present as such at all, are disguised by the folding, and must be discussed among the more problematical veins.

Stigma.—The stigma or pterostigma is a thickening of the marginal portion of the wing in the neighborhood of the apical part of Sc (Sc_2) and R_1. It shows plainly in a great many beetles belonging to the Adephaga, Palpicornia and Staphylinoidea, and will be used below as a means of identifying the distal sector of R_1.

THE FORKING OF THE VEINS.

Subcosta is so completely fused with costa and radius that a discussion of its outer course can lead to no certain conclusion. I have postulated a forking beyond the hinge, to account for one of the obscure cells at this point in the Carabidæ and the double thickening of the stigma in Hydrous. The fading out of the trachea of R_1 in those forms that have one at all, shows that the terminal portion of R_1 has been captured by Sc_2 (a common occurrence). In the more specialized forms Sc_2 is one of the tracheæ that persists, and with the disappearance of true veins in the apical part of the wing, takes an oblique course toward the apex regardless of what traces of veins remain (Fig. 5, 6a; but compare Fig.6). The tracheæ of M and 2d A in certain forms behave similarly.

Radius.—R_1 is a vein that tends strongly to weaken and disappear, its terminal portion fusing with Sc. In several Coleoptera there is a plain anterior branch of the radial stem which continues in the common cavity of Sc and R beyond the point at which the main radial trachea leaves it (Fig. 2) . There is no reason to doubt that this is R_1, and that the main trachea, beyond the bifurcation, is the stem of R_s.

Beyond this point tracheation fails to give evidence, as the subdivisions of R_s are unstable in all the forms yet studied. The interpretation laid out on the hypothetical plan (Fig. 1) is based on the assumptions, *first*, that the apex of the wing in a low holometabolous insect is to be sought in the neighborhood of R_3, and *second*, on the plain connection of the stub here identified as R_{4+5} across to the stem of R_s in such forms as Tetracha (Fig. 13). The terminal veining here introduced into the hypothetical plan is nowhere so plain as in Hydrous, but well-marked traces survive, not only in the other large Hydrophilidæ, but in the Lamellicorns as well. This group of veins might likewise be interpreted as M_{1+2}, but the strong tendency to reduction in the median and cubital systems of the Neuroptera would suggest a similar interpretation here.

In the Polyphaga the base of R_s is atrophied, leaving the outer part as an apparent backward-projecting spur—the *radial recurrent* (Rr). The second radial cross-vein, on the atrophy of a segment of R_s crossing the main folds, swings into this portion of R_s, and is usually reckoned with it as a portion of the radial recurrent, which would then be designated according to the usual terminology as R_s & 2d r.

Media.—Media has become two-branched in practically all the known Neuroptera, and in many is reduced to a single stem, forking only at a point corresponding to the nearly veinless apical region of the Coleoptera. The presence of but a single medial trachea in all the forms studied, save for unstable terminal branching, would suggest here that no branches need be sought save in the terminal portion of the wing. I have marked as medials those terminal veins that seem to connect most closely with the medial stem. The main trachea in the Adephaga, runs out in the vein here marked M_4 (Fig. 3); in the Polyphaga swinging into the same vein with Cu toward the margin. The two veins that survive in the generality of forms are marked M_1 and

M_4 because they are the extreme members of the complex group shown by Hydrous. They might be considered M_{1+2} and M_{3+4} if the extra veins of Hydrous be considered secondary.

In almost all forms (except a few Adephaga and Cupes) the base of media fades out, leaving the main part of it attached at the apex only. This sector of the vein is known as the *medial recurrent* (Mr).

Cubitus.—There is never but one vein supplied by the cubital trachea (leaving out of account the vein here treated as 1st A). Many Neuroptera also have only a single corresponding cubital, or a single main vein supplemented by some secondaries. To judge by the arrangement of these terminal branches the missing cubital branch has either fused completely with the surviving one, or has atrophied on the posterior side of it. At this point some Lamellicorns have a trachea not represented by any very distinct vein in the imago, which may possibly be the missing Cu_2, but is more likely a last trace of 1st A.

In the Hydrophilidæ and Haliplidæ (Figs. 19 to 23), Cu runs toward the margin as an independent vein. Comparison with these two families shows that in the remaining Adephaga the apex of Cu has disappeared by atrophy, while the double trachea suggests that in the Polyphaga it has fused with M_4.

First anal.—This is simple. With the atrophy of its base the cross-vein cu-a remains to connect it with the stem of cubitus (Hylecœtus, Fig. 40). In some forms, as in the Lampyridæ (Fig. 32) it is not clear whether it is the base of the main vein or the cross-vein, which has disappeared.

Second anal.—The second anal trachea divides, at the maximum, into three branches. The first corresponding vein has been universally considered a branch of the vein here designated 1st A, but if that is the case the extraordinary course of its trachea, which actually has to turn basad in some Buprestidæ, to enter its cavity, and which may run for some distance in a common vein-cavity with the first anal trachea without fusing with it, remains entirely unexplained. This first branch is doubtless the one that has disappeared in the Tenebrionidæ and Adephaga (where there is no corresponding trachea); but in the higher Phytophaga it seems rather to be 1st A that has vanished, as there is no trace of a first anal trachea arising from Cu. The second branch of 2d A has nothing extraordinary, and receives the unbranched second anal trachea in the Tenebrionidæ (in some specimens only of which the third branch also receives a tracheal twig). The third branch has apparently evolved in two distinct ways. In a few forms it is entirely independent (as in Attagenus, Fig. 35, and many Buprestidæ, Fig. 34). The next, and perhaps most primitive condition, is for it to be connected by a cross-vein to the upper fork of 3d A, as plainly shown in *Cebrio* (Fig. 30). It is my belief that the same condition holds in the other Elateridæ (s. l.) and Lampyridæ, where there are three anal twigs below the second anal furrow, and the vein bounding the wedge-cell is transverse and tends to disappear by atrophy (Alaus, Pyrophorus, Calopteron). In most forms, however, the apex of this branch has

obviously fused with the first branch of 3dA, forming a pointed wedge-cell, and leaving only two terminal branches below the second anal furrow (compare Figs. 32 and 37).

On the basal side of the wedge-cell there is a short oblique vein running from the stem of 2d A to the upper branch of 3d A. Whether this is a fourth branch of 2d A, which has permanently joined 3d A_1, or a cross vein, is not clear. Occasionally it contains a trachea arising from 2d A, but tracheæ in other crossveins are not entirely unknown. In the pupa of Tenebrio and Dytiscus it is more definitely transverse than in the imago, a significant point.

Third anal.—The third anal vein forks once near the base of the wing as a rule. Sometimes both branches have a trachea, sometimes only the lower. The upper is connected to 2d A by two transverse veins, enclosing the wedge-cell between them. In a few forms the third anal is simple, presumably by the atrophy of its upper branch, which is broken, for instance, in the Lamellicorns (Fig. 62).

Fourth anal.—The anterior branch of the fourth anal vein is present in all save markedly reduced species, and contains a trachea in all species with fairly complete tracheation. A second branch is present in most Adephaga, running along the inner margin of the wing, and in a few a third, running back and stiffening the alula. This is the superficial interpretation; it is not impossible that a detailed comparison with the Neuropteroids will result in a different interpretation. In particular the vein here considered 3d A_2, may possibly belong in fact to 4th A.

CROSS-VEINS.

It is evident that the Coleoptera are descended from a form with a considerable number of cross-veins, which were tending at least to take definite positions. Assuming that they were not wholly definite, the survival of certain ones was doubtless determined by the folding, which necessitated a more complete cross-bracing than in the Trichoptera and Lepidoptera, for instance. The humeral has already been taken up. Discussion of other cross-veins in the costal region would be useless, as the longitudinal veins are almost completely fused. Comparison with the Neuroptera would prepare one for a large number of such veins, but the few forms in which C and Sc are separate (e. g., Cupes, Fig. 12) show no sign of them.

Between R_1 and R_s there is plain evidence of several cross-veins. For the region basad of the pivot-fold, the Hydrophilidæ, and especially the primitive Elaters, give the best evidence. They plainly show two cross-veins, one variable in position, but well before the fold of the wing, the other stiffening the edge of the first fold, being the outer part of the vein marked R_{s+r} in Fig. 30. The latter is obscurely indicated in several Adephaga, but there is no trace, apparently, of the first, the radial fork coming just before the hinge.

Beyond the hinge the Hydrophilidæ show only faint traces of veins, and most Polyphaga none at all; but the Adephaga have two well-developed cross-veins, which may be called 3d r and 4th r. The

vaguely defined vein which stiffens the fold half way between the last and the apex in the Gyrinidæ, for instance, would then be 5th r.

There would be possible a second explanation of these veins; namely, that the pivot fold of the Adephaga corresponds not to that of the Hydrophilidæ and Tenebrionidæ, etc., but to that of the Coccinellidæ and Malachiidæ. This would reduce the number of radial cross-veins postulated, as it would make the two main cross-veins of the Adephaga homologous with the two of the Polyphaga, but it would involve a reversal in direction of the two principal transverse folds. It would also leave the faint cells of Hydrous unexplained. This interpretation seems to me less probable, but must be taken into account, considering the variable character of the folding in all parts of the wing. There is much room for some one with care and patience to make a study of the wing folding, which shows much more variety of type than Woodworth's account would imply. The forms intermediate between the Adephaga and Polyphaga (Staphylinoidea in the broad sense; Figs. 24 to 28) are all highly modified, and many of them minute, with reduced venation; so that very careful analysis will be necessary to interpret them.

Between radius and media (as interpreted by the tracheæ) the Adephaga have single fully formed cross-vein, marked r-m. In some species of Cupes this has migrated far toward the base of the wing, (Fig. 4), but in other species (Fig. 12), and in Omma, it is normal. In a few Elaters (Fig. 30), it is plainly shown, as a distinct, though faint, vein connecting the base of R_s with M, but as a rule in the Polyphaga it is lost, or incorporated indistinguishably in the radial recurrent. (Compare Hydrocharis, Fig. 22, with Hydrous, Fig. 20).

The obvious cross-vein of the Polyphaga appears to be a second, the surviving element of a complex net-veined area, apparently, which is faintly visible in some Cerambycidæ and Chrysomelidæ, but has been mostly obliterated to form the large and complexly folded central cell. Aside from the Phytophaga a few other forms show aberrant veins or thickenings that may be remnants of this system, notably the Cupedidæ (Figs. 4, 12) and Ostomidæ (Fig. 49). How much is original and how much secondary in the complicated conditions of the Malachiidæ (Fig. 58) and Coccinellidæ (Fig. 56) may sometime appear from more detailed study, or the discovery of transitional forms.

A third radiomedial cross-vein is indicated at the outer boundary of the central cell, connecting the stem or stub of R_{4+5} with M_1. It must be through the survival of this cross-vein that R_{2+3} in the Lamellicorns gets its connection with the medial stem.

There are two medio-cubital cross-veins, enclosing the so-called *Oblong* cell (O) of the Adephaga and Cupedidæ. The more basal of these may receive a trachea from media, but I am inclined to consider this not significant, as the assumption that it is really the stem of M_{3+4} will not work out into any logical interpretation of the marginal veins. In the more specialized Adephaga (Fig. 13) and the Hydrophilidæ there is only one cross-vein. The usual explanation is that one or the other has atrophied. It seems more simple to assume the

two have fused, especially as in several Carabidæ there is a partial fusion. The families in which there is a single cross-vein are the Cicindelidæ (save the genus Pogonostoma, as figured by Horn, Gen. Ins., 82, pl. 5, f. 52), Rhysodidæ and Hydrophilidæ, with a few stray genera of other families. In the remaining Polyphaga the cross-veins are obliterated by the fusion of M_4 with Cu.

The cross-vein cu-1st a is mentioned under the discussion of that vein. In Cupes alone there is a second cubito-anal cross-vein in the outer part of the wing.

A very important cross-vein is the one from the base of 1st A or from the fused root of Cu+1st A to the base of 2d A. It is doubtless homologous to the anal cross-vein of the Trichoptera and lower Lepidoptera. In all forms but the Cupedidæ the extreme base of 1st A is transverse and appears (with the disappearance of a sector of 1st A) as a part of it. I will refer to this combined vein as the anal arculus (a. arc.) as its relation to 1st A is exactly that of the arculus to media in the Odonata and some other orders. This vein appears in all the Adephaga and Staphylinoidea, excluding the Histeridæ, but nowhere else. Another cross-vein 1st-2d a appears in the outer part of the wing in Cupes oculatus (Fig. 12), but in most other Coleoptera it is obliterated by the anastomosis of the anterior branch of 2d A with 1st A.

Two cross-veins may be assumed between 2d A and 3d A, enclosing the wedge-cell (W) between them, but as noted in the discussion of 2d A, it is not quite certain that the inner is a cross-vein, and the outer is preserved only in the Elateridæ, Lampyridæ, and a few related forms.

There is in the Cupedidæ and Adephaga a transverse vein at the extreme base between 3d A and 4th A, but its significance is uncertain.

FOLDING.

I figure folding diagrams of a few typical Coleoptera (Figs. 7, 16, 21, 25, 27, 61). In these the portions of the wing reversed (turned under or over) in the folded wing are shown dark, those which remain right side up are white. Convex folds are indicated by a broken or serrate line, concave by an even line. Regions of irregular crumpling, and regions not completely folded under, are striated.

It can be seen that the folding is highly complex, and may differ in details in closely related forms, though of the same fundamental plan (compare especially Harpalus, Fig. 16, with Dytiscus, Fig. 7). The Dytiscid and Hydrophilid foldings are homologized by d'Orchymont differently than by me, with the result that he considers the vein I call media in the Adephaga to be rather the radial recurrent. I have given first weight to the fact it always contains the medial trachea, and have assumed that the area at the hinge that folds under has become more extensive in the Adephaga, and has crossed the medial vein. It should be also noted that the area homologous with the reversed portion in the cell of the Adephaga is not the large reversed portion of the Polyphaga, but the relatively inconspicuous crumpled strip

above cubitus, as shown by the fact that it alone constantly reaches the base of the wing. Hydrocharis (Fig. 22) and other forms with a short radial recurrent, show the condition better than Hydrous (Fig. 21).

DISCUSSION OF CERTAIN FORMS.

It is not the province of one not a Coleopterist to go into the detailed discussion of the relationships of the Coleoptezous groups, but some points come out so clearly that they should be emphasized. First it is strikingly clear that Gahan's system comes far nearer to agreeing with the evidence of the wings than any other known to me.

Adephaga.—(Figs. 2, 3, 5, 7, 10, 11, 13–19). If venation means anything at all this is a homogenous group, and includes the Rhysodidæ as a hardly aberrant member. Whether the Cupedidæ should also be included is a discussed question. They certainly have one point of divergence from all the typical Adephaga in venation, namely, the preservation of the first branch of 2d A as an apparent branch of 1st A. The Haliplidæ alone of the forms examined have preserved the tip of Cu; as have the Pelobiidæ as figured by d'Orchymont. The subfamilies of Carabidæ are not obviously indicated by the venation, even Pseudomorpha being hardly aberrant. Fragments of 2d r appear in a few forms (Harpalus, Fig. 15). R_{4+5} often appears as a strong stub (Fig. 13) but never bears terminal branches. Amphizoa does not differ obviously from Dytiscus, both having a long straight 1st A, with a thickening below it. The Gyrinidæ differ mainly in having a thickening above the outer part of the stem of M, of uncertain significance. It might be interpreted as a trace of M_{1+2}, but this would not lead to any logical working out of the distal part of the wing.

Cupedidæ.—(Figs. 4, 12). The characters of this family have been abundantly discussed. The difference between the superficially almost identical species C. capitatus and C. oculatus is curious. Note espepecially 1st r-m, 2d A_1, the wedge-cell, and the position of the anal cross-veins.

Staphylinoidea.—Silpha (Figs. 24, 25) and Necrophorus are closely related, in fact almost identical in venation as well as wing-folding, and show a marked resemblance to the Staphylinidæ (Fig. 28). Note the preservation of the anal arculus, the principal fold of the wing lying before the thickened stigma, and the simplified anal region without any visible connection between 2d A and 3d A. There is practically nothing to connect this group of families with either the Adephaga or higher forms, and they might well be a survival of some earlier type. The alula of the elytron is preserved, as in the Adephaga and Hydrophilidæ. The folding is unique, but perhaps a little more easily interpreted as Adephagous.

Brathinus, an interesting intermediate form in body characters, is too reduced to have a significant venation.

Necrophilus (Figs. 26, 27) is far more widely separated from Silpha than it from the Staphylinidæ. The folding is unique (Fig. 27), the wing folding over just beyond the stigma. The genus, while perhaps

Silphid, is obviously out of place between Silpha and Necrophorus. I believe the small Silphidæ will go with it; Prionochæta at least shows essentially the same wing.

Palpicornia.—(Figs. 20-23). This group is interesting as alone showing a complex apical venation, as well as being the only one of the Polyphaga to preserve traces of the radial cells beyond the fold. The folding at the costal margin is as in the Adephaga while the remainder of the wing is almost typically Polyphagan. The radial recurrent obviously belongs more to the first r-m than to the base of Rs, in several genera almost connecting with the stem of M. One anal (2d A_1) is always lost. The family is primitive in preserving M_4 and Cu as separate veins, like the lower Adephaga and perhaps the Staphylinoidea, but unlike all the higher forms.

The smaller genera (such as Sphæridium, Fig. 23) show a striking resemblance to the Lamellicorns, that may possibly be significant, as the latter show distinct traces of distal veining.

Buprestidæ.—(Figs. 6a, 34). A student here is working on this family, which as Gahan notes shows no close resemblance to the Elaters. It is evidently a survival, and is one of the very few that has three free branches to 2d A. The lack of folding of the wing is not characteristic of the family as a whole, since Brachys folds normally.

Elateroidea.—(Figs. 30–33). The Elateridæ (Fig. 31) and Lampyridæ (Fig. 32) form a very well defined group in venation, to which all the small families of Sternoxia but the Rhipiceridæ will attach themselves. Cebrio (Fig. 30) is most primitive, and basic for interpreting the anal region. A general characteristic is the transverse outer end of the wedge cell (which fails in several genera by the loss of the cross-vein, and in Tharops alone by its obliquity). Another is the position of 1st r in all but a few aberrant groups markedly basad of the radiomedial. The folding is also uniform, being a double chevron-fold in the apex, rather like that of the Heteromera and lower Buprestidæ, but utterly unlike the Malachiidæ. The Lampyridæ are exactly like the most specialized Elaters, differing from the typical ones only by the loss of the cross vein cu-a. If the venation means anything they are degenerate rather than primitive.

Malachiidæ (*Melyridæ*).—Figs. 57, 58). These so far as the wings show have nothing whatever to do with the Lampyridæ, and may be a survival of a primitive type, especially if the transverse vein from the cell to the inner margin is really an independent Cu. The folding is very complicated and I have not worked it out fully. The nearest thing to it seems to be in the Coccinellidæ (Fig. 56). There are two pivot-folds at the costa, the more posterior of which corresponds in its manner of folding with that of the Adephaga and Hydrophilidæ, the more anterior with that of the Bostrychidæ and Byrrhidæ. The anal region is degenerate and gives no help. A large South American species shows no more veins than Malachius.

Dascylloidea.—(Figs. 37, 38). The Dascyllidæ and Rhipiceridæ are almost identical in venation, and distinguished mainly by the lack of the special characters of the other groups, in this resembling the lower

members of the Clavicornia, and the Macrodactylia. At present several members of this group are considered Buprestidæ and one or two primitive Elateroids are standing as Dascyllidæ. The Helodidæ are not even remotely related, but vaguely suggest the Dryopidæ and the Nitidulidæ.

Macrodactylia.—(Figs. 41, 42). It is an utter mystery to me how Kolbe, with any consideration of the venation, could separate the Parnidæ in three distinct superfamilies. There are differences, but they are mainly of the character of degree of development, and could be matched in almost any family of Coleoptera containing small species. He seems to have particularly emphasized the development of the medial recurrent. In venation the series has no particular characters, unless perhaps the tendency for R_3 to be stronger than M_1. Psephenus has preserved a radial cross-vein, while the European Dryops viennensis (Fig. 41) has preserved the usual five anals in the main group, which are reduced in the others. The folding is based on the Hydrophilid type, but this may not be significant, as this was presumably the original type for the Polyphaga generally; the preservation of 2d A_1 forbids derivation directly from the Hydrophilidæ.

Lymexylonidæ (Fig. 40).—I have only been able to study two forms. Hylecœtus tenebroides has nothing aberrant about it, and could perfectly well belong to the Heteromera, which themselves are not widely unlike many other Serricorns. Atractocerus is so modified as hardly to be significant, and is strangely suggestive of the Meloidæ, but could equally be derived from Hylecœtus.

Cleridæ.—(Fig. 48). This family, which with the Malachiidæ makes up the Trichodermata, shows none of the primitive characters of the Malachiidæ. On the other hand it is not strongly distinguished in venation from the Ostomidæ.

Dermestidæ.—(Figs. 35, 36). The Dermestids show at least three radically different types of venation. Attagenus (Fig. 35) is primitive in having the wedge-cell open by the lack of fusion of 2d A_3 and 3d A_1, as well as in the presence of an ocellus. It resembles nothing else whatever. Dermestes (Fig. 36), represents the ordinary Dermestid type, and while well characterized, it would not be out of place in the Dascylloids so far as venation is concerned. The 2d anal furrow seems however, to have three veins below and two above it, which would suggest a more primitive position for it also. Anthrenus is reduced, but offhand would suggest another family type, nearer the normal clavicorns.

Byrrhidæ (Figs. 51, 52).—These do not suggest the Dermestidæ at all in venation, nor anything else I have studied except possibly Mycetophagus. There are two pivot-folds, as in the Malachiidæ, but otherwise no very close likeness. The Mycetophagidæ (Fig. 53) are more primitive in preserving the wedge-cell, the Byrrhidæ in having cross-vein cu-a. Both show traces of complexity in the vein r-m, but this may be a secondary effect of the folding.

Ostomidæ (*Trogositidæ*) (Figs. 49, 50).—The most distinctive character of this family seems to be a tendency to chitinize the area of the wing crossed by r-m, in the form of an arrowhead-shaped mark,

exactly as in the Cleridæ, and to a rather strong preservation of the tip of M_1. A chitinization beyond the pivot-fold alone gives a slight special likeness to the Hydrophilidæ, with which they agree in type of folding.

Heteromera (Figs. 6, 43–46).—There is nothing about the venation of the Heteromera to separate them in two groups corresponding to those in Leng's Catalogue, and on the whole not much that is distinctive. The folding, as in the Hydrophilidæ, Buprestidæ, Elateroidea, Dascylloidea, Dermestidæ, Macrodactylia, etc., is of what may be called the normal type, dominated by a double pivot fold in the same position as in the Adephaga. The venation of the same region is rather simple, and possibly nearest to the Buprestidæ which fold their wings, and the Ostomidæ. In the anal region 2d A_1 is invariably lost, but the type is that normal in families mentioned, in other points. The *Erotylidæ* have the same venation, and should be re-examined as to homogeneity as a family, as some of them have heteromerous tarsi.

Meloidæ.—The Meloidæ (Fig. 47) at first sight are markedly divergent from the remainder of the Heteromera; but the points of divergence seem merely to be the result of reduction. The radial cell is lost, and the outer ends of the radial and medial recurrents have become nearly transverse, and continuous with the radiomedial crossvein, giving a characteristic appearance to the outer part of the wing. In the anal region there are three simple veins, with a chevron-shaped structure between the second and third, toward the base. At first sight this arrangement seems unique, but is easily derivable from the normal heteromerous type by the loss of the lower side of the wedge-cell and vein 2d A_3+3d A_1. The Trictenotomidæ of Africa seem to be intermediate.

The *Rhipiphoridæ* have so completely lost their veining that they might be interpreted in any way. The few traces of veins left are not specially suggestive of the Meloidæ, but the other characters and habits place the family in this neighborhood. The *Stylopidæ* are also extremely reduced; but the venation, so far as preserved, seems to agree with that of the Meloidæ.

Nitidulidæ (Figs. 54, 55).—Phenolia grossa is a reduced form, but with an extraordinarily complex type of folding, which I have not tried to work out in detail. The recurrents form a deep loop, exactly as in the Histeridæ, but the character is as likely as not to be due to convergence, as the forms have no other special likeness.

Histeridæ (Fig. 29).—Ganglbaur by some extraordinary slip put this family in the Staphyliniformia on venational characters, stating that the medial recurrent is absent. In fact Mr is an exceptionally strong and heavy vein, as well as Rr, and both appear to take part in the folding of the wing, which resembles the Staphylinidæ in no way. Save for the preservation of R_5 as a vein in the outer part of the wing, the form would be easily derivable from the other clavicorns, by an increase of the folded portion. In any case, as there is no trace of the anal arculus, and the recurrents are fully developed, the relationships

of the form are to be sought in the latter families and not in the Staphyliniformia.

Coccinellidæ (Fig. 56), *Endomychidæ*.—These two families agree in the curious anal system formed of two loops, and the curious manner of folding, with two hinge-folds working together. The venation is adjusted to this folding, and reduced, even in species as large as Epilachna, so that except as it emphasizes the isolation of the family the venation is of little use. What likeness there is, is to the Malachiidæ.

Bostrychoidea (Figs. 59–61).—The Bostrychidæ are characteristic, and the Ptinidæ resemble them closely. The folding is very simple (Apate, Fig. 61) and derived from a type with anterior pivot-fold, such as the Melachiidæ. In venation the principal character is the origin of M_1 directly from the cross-vein, whereas it is free in almost all the other Polyphaga. Dinapate is not aberrant in the least.

Lamellicornis (Fig. 62).—All the Lamellicorns have a single type of venation. There is a strong tendency for the central cell to be obvious, and to keep its rounded form, and R_3 frequently switches its attachment from the upper to the lower side of it, as in the figure. The anal region is characterized especially by the reduction of the upper fork of 3d A to a short stub running across toward 2d A, the complete disappearance of the wedge-cell, and the detachment of 1st A and the two upper branches of 2d A, which show as fine chitinous streaks or disappear entirely. I have seen no form in which all three were distinct; in some 1st A is visible close to the junction of M_4 with Cu (Kühne, Fig. 21), in others it is 2d A_1 that is preserved; 2d A_2 is usually present. The radial cross-vein appears always to be absent, but the apical system of veins are more distinct than in any other family save the Hydrophilidæ, R_{4+5} often showing as a distinct stub, connected with R_{2+3}, and Mr showing a decided angle at the point where M_1 is presumably given off.

In general the Trogidæ and Lucanidæ have a larger cell below the base of 2d A, but the families are not well separated in venation.

Phytophaga (Figs. 63–68).—This group tends strongly to simplification of the anal region, but the lower forms are quite typical. There is, with a few exceptions, a spur on the outer side of r-m, and rarely one on the inner side also, or even more complex structures involving the first radiomedial as well. The central cell is apt to be well-outlined, and M_1 usually is strongly developed and attaches to it. Aberrant forms, however, like Distenia undata, figured, violate all the definitions of the group, and make it undefinable on venation. In Prionus the anal region is almost like that of Hydrous. On the other hand the typical venation, with a spur on the second radiomedial cross-vein, is universal in the Chrysomelidæ and Mylabridæ (Bruchidæ) and is carried over into the Anthribidæ of the Rhynchophora, whose position in the group cannot be challenged. The higher Rhynchophora, of course, are highly modified in connection with their peculiar wing folding, though even they show some slight trace at times of the characteristic spurred cross-vein.

The folding is of the Hydrophilid type.

SUMMARY.

The venation of the Coleoptera is based on the same fundamental plan as that of the Neuroptera and other Holometabola, but with a rather large number of cross-veins. Costa is typical, not always marginal; subcosta normal, concave, usually fusing with radius; radius with R_1 obsolescent, fusing with Sc, Rs sharply divergent from R_1 at origin, and usually obsolescent at root, then broken by the principal fold of the wing, R_2 and $_3$ represented by parallel more or less rudimentary veins toward the costa, R_{4+5} bending down sharply on the outer side of a *central cell* where all the folds of the wing tend to converge, then turning out, and when complete ending in one branch near apex and one far below, near M_1. (Hydrophilidæ, Histeridæ), usually reduced to a short stub (Adephaga, Scarabæoidea) or lost. Media oblique from R to Cu near root, then obsolete a distance, then showing as a spur attached at its apex to Cu, in the outer part of the wing with two divergent branches, representing M_1 and M_4; Cu simple, strong to fold, then usually lost beyond or fused with M_4; anals complexly anastomosing, typically with 6 or 7 terminations, of which only one belongs to 1st A.

The Haliplidæ are generalized among the Adephaga, the Amphizoidæ very close to the Dytiscidæ.

The Hydrophilidæ contrast with all the other Polyphaga in the preservation of both M_1 and Cu, and often in a more or less complete apical venation. Sphæridium suggests the Lamellicorns.

The Silphidæ are very near the Staphylinidæ in venation; the Necrophilus group less close. They form an isolated group apparently not nearer the Polyphaga than Adephaga.

The Histeridæ have nothing to do with the Staphyliniformia, but are Clavicorn or isolated.

The Elateridæ and Lampyridæ are closely related, and the venation suggests that the Lampyridæ are degenerate from an early elater type, not primitive.

The Malachiidæ, Coccinellidæ and some other families seem to make a separate group, which certainly has nothing to do with the Lampyridæ or Cleridæ.

The Rhipiceridæ are Dascylloid, not Elateroid, as noted by Gahan.

The Cleridæ are possibly related to the Ostomidæ.

The Lymexylonidæ are not especially generalized, and suggest the point of origin of the Heteromera.

The Heteromera show no sign of double origin where now divided; the Meloidæ on the other hand, contrast strongly with the families associated with them, apparently resembling the Rhipiphoridæ and Stylopidæ.

The Clavicornia are a heterogeneous group, on which light will certainly be thrown by the venation and folding.

EXPLANATION OF PLATES.

ABDREVIATIONS USED.

C—Costa.
Sc—Subcosta.
Sc_1, Sc_2—its branches.
R—Radius.
R_1, R_2, R_3, R_4, R_5—its branches.
Rs—Stem of radial sector.
M—Media.
M_1, M_2, M_3, M_4—its branches.
1st A—First anal vein.
2d A—Second anal vein.
$2dA_1$, $2dA_2$, $2dA_3$—its branches.
3dA—Third anal vein.
$3dA_1$, $3dA_2$—its branches.
$4thA_1$—Fourth anal vein.
$4thA_2$—Presumed second branch of fourth anal.
hum—humeral cross-vein.
arc—arculus.
a. arc—anal arculus (cross-vein 1st-2d and base of 1st A).
r—radial cross-veins.
r-m—radiomedial cross-veins.
m-cu—mediocubital cross-veins.
cu-a—cubitoanal cross-veins.
1st-2d a, 2d-3d a—interanal cross-veins.
O—Oblong cell (2d M).
W—Wedge-cell (2d 2d A).
st—Pterostigma.

PLATE XXIX.

Fig. 1. Hypothetical plan of wing venation of Coleoptera, based mainly on Cupes (base and cell), Cebrio (anal region) and Hydrophilus (apex). The conventional symbols for the veins and cells are used, namely:
Fig. 2. Tracheation of wing of imago of Calosoma species. The tracheæ are shown as solid lines, the veins stippled.
Fig. 3. Tracheation of imago of Dytiscus verticalis.
Fig. 4. Venation of Cupes capitata.

PLATE XXX.

Fig. 5. Tracheation of young pupa of Dytiscus, from a preserved specimen. The tracheæ are shown so far as made out, by solid lines, the vein-cavities stippled. The specimen is imperfect and a fresh wing would probably show more tracheæ and veins.
Fig. 6. Tracheation of young pupa of Tenebrio molitor (about one day after pupation). The tracheæ are all as shown in one mount, the veins restored by comparison with the late pupa and imago.
Fig. 6a. Tracheation of young pupa of Agrilus ruficollis. Slide by Henry Good.
Fig. 7. Diagram of wing-folding of Cybister. The portions of the wing reversed in folding are shown black. Concave folds are indicated by even lines, convex ones by toothed lines. Regions of the wing, which are half folded over, or crumpled, are hatched.
Figs. 8, 9. Folded wing of Apate capucina (Polyphaga, Bostrychidæ); the veins cross-hatched and concealed portions dotted in. Dorsal and ventral views.
Figs. 10, 11. Folded wing of Colymbetes sculptilis (Adephaga, Dytiscidæ); like Figures 8 and 9. Dorsal and ventral views.

PLATE XXXI.

Fig. 12. Cupes oculata (Cupedidæ). Slide by courtesy of C. T. Brues.
Fig. 13. Tetracha virginica (Cicindelidæ).
Fig. 14. Galerita janus (Carabidæ).
Fig. 15. Harpalus caliginosus (Carabidæ).
Fig. 16. Same; folding plan (compare Figure 7).
Fig. 17. Pheropsophus æquinoctialis (Carabidæ; South America).
Fig. 18. Trogus glaucus (Dytiscidæ; South America).
Fig. 19. Cnemidotus edentulus (Haliplidæ).
Fig. 20. Hydrous triangularis (Hydrophilidæ).
Fig. 21. Same, folding plan (compare Figure 7).
Fig. 22. Hydrocharis obtusatus (Hydrophilidæ).
Fig. 23. Sphæridium scarabæoides (Hydrophilidæ).

PLATE XXXII.

Fig. 24. Silpha species (Silphidæ).
Fig. 25. Same. Folding plan (see Figure 7).
Fig. 26. Necrophilus hydrophiloides (Silphidæ?).
Fig. 27. Same. Folding plan (see Figure 7).
Fig. 28. Staphylinus maculosus (Staphylinidæ).
Fig. 29. Hister inæqualis (Histeridæ; Europe).
Fig. 30. Cebrio bicolor (Cebrionidæ).
Fig. 31. Elater discoideus (Elateridæ).
Fig. 32. Photuris pennsylvanicus (Lampyridæ).
Fig. 33. Pactopus hornii (Throscidæ).
Fig. 34. Dicerca lurida (Buprestidæ). Slide by Henry Good.
Fig. 35. Attagenus pellio (Dermestidæ).

PLATE XXXIII.

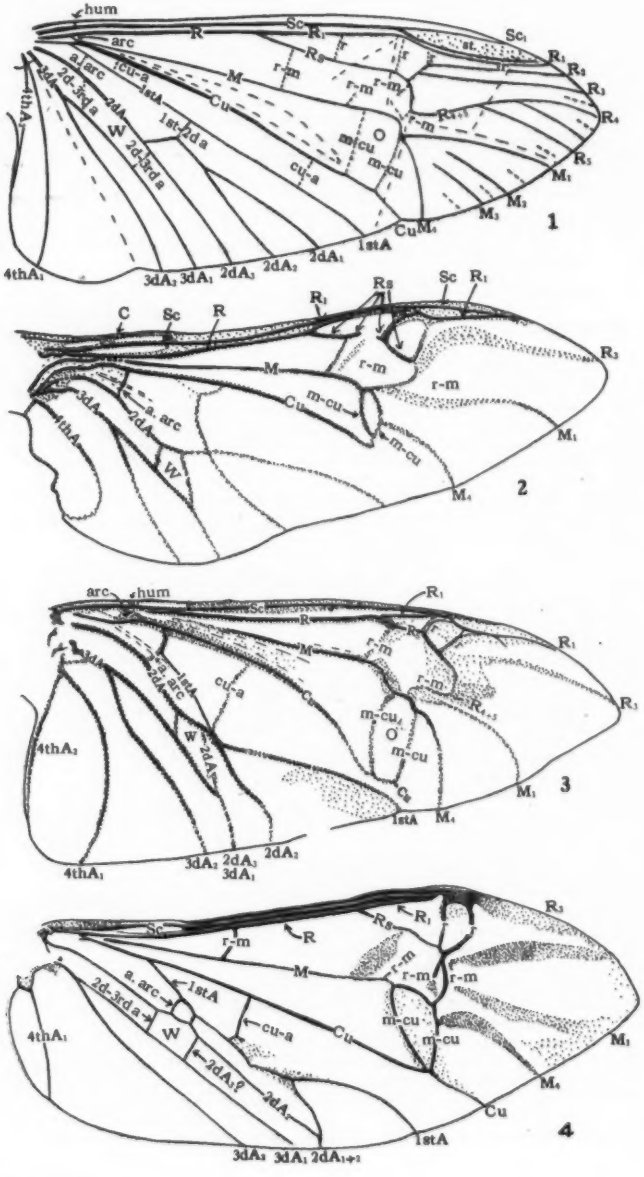
Fig. 36. Dermestes marmoratus (Dermestidæ).
Fig. 37. Sandalus porosus (Rhipiceridæ).
Fig. 38. Dascyllis plumbeus (Dascyllidæ).
Fig. 39. Cucujus clavipes (Cucujidæ).
Fig. 40. Hylecoetes tenebroides (Lymexylidæ; Europe).
Fig. 41. Dryops viennensis (Dryopidæ; Europe). Our species have lost 2d A_1.
Fig. 42. Heterocerus pallidus (Heteroceridæ).
Fig. 43. Tenebrio molitor (Tenebrionidæ).
Fig. 44. Penthe pimelia (Melandryidæ).
Fig. 45. Mycterus scaber (Melandryidæ).
Fig. 46. An undetermined species representing the Cistelidæ.
Fig. 47. Pomphopoea sayi (Meloidæ).

PLATE XXXIV.

Fig. 48. Trichodes apivorus (Cleridæ).
Fig. 49. Trogosita virescens (Ostomidæ).
Fig. 50. Tenebroides sp. (Ostomidæ).
Fig. 51. Byrrhus sp. (Byrrhidæ).
Fig. 52. Nosodendron unicolor (Byrrhidæ).
Fig. 53. Mycetophagus species (Mycetophagidæ).
Fig. 54. Glischrochilus fasciatus (Nitidulidæ).
Fig. 55. Phenolia grossa (Nitidulidæ).
Fig. 56. Coccinella transversa (Coccinellidæ).
Fig. 57. Malachius aeneus (Melyridæ; Europe).
Fig. 58. Collops bipunctata (Melyridæ).
Fig. 59. Dinapate wrighti ♀ (Bostrychidæ). Slide by courtesy of Henry Dietrich.

PLATE XXXV.

Fig. 60. Apate capucina (Bostrychidæ; Europe).
Fig. 61. Same. Folding diagram; compare Figures 7, 8 and 9.
Fig. 62. Lucanus dama (Lucanidæ).
Fig. 63. Asemum nigrivenum (Cerambycidæ).
Fig. 64. Distenia undata (Cerambycidæ).
Fig. 65. Leptura canadensis (Cerambycidæ).
Fig. 66. Caryoborus arthriticus (Mylabridæ-Bruchidæ).
Fig. 67. Donacia aequalis (Chrycomelidæ).
Fig. 68. Entomoscelis adonidis (Chrysomelidæ).
Fig. 69. Neuronia species (Trichoptera). Hind wing for comparison with the hypothetical type of the Coleoptera.
Fig. 70. Chorista australis (Panorpata; Choristidæ; Australia). After Esben-Petersen. Hind wing.
Fig. 71. Chauliodes pectinicornis. (Neuroptera; Sialidæ). Hind wing.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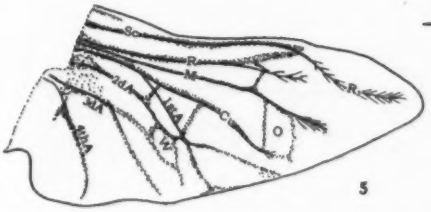

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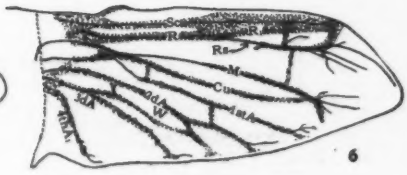

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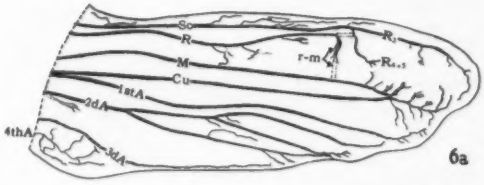

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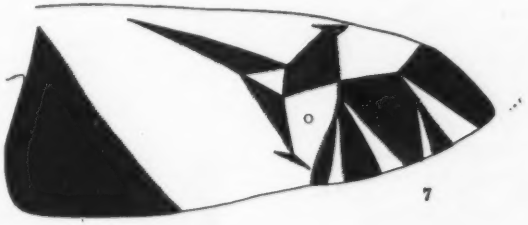

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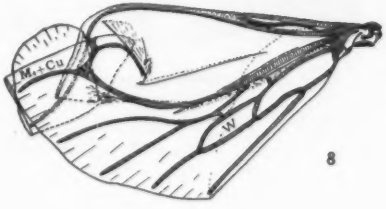

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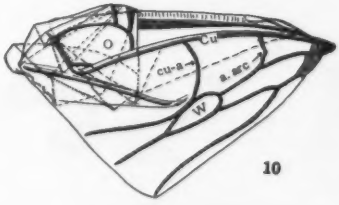

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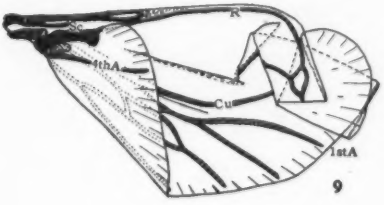

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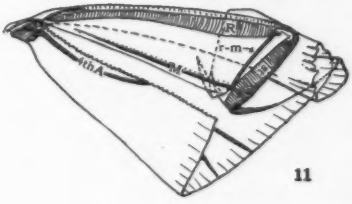

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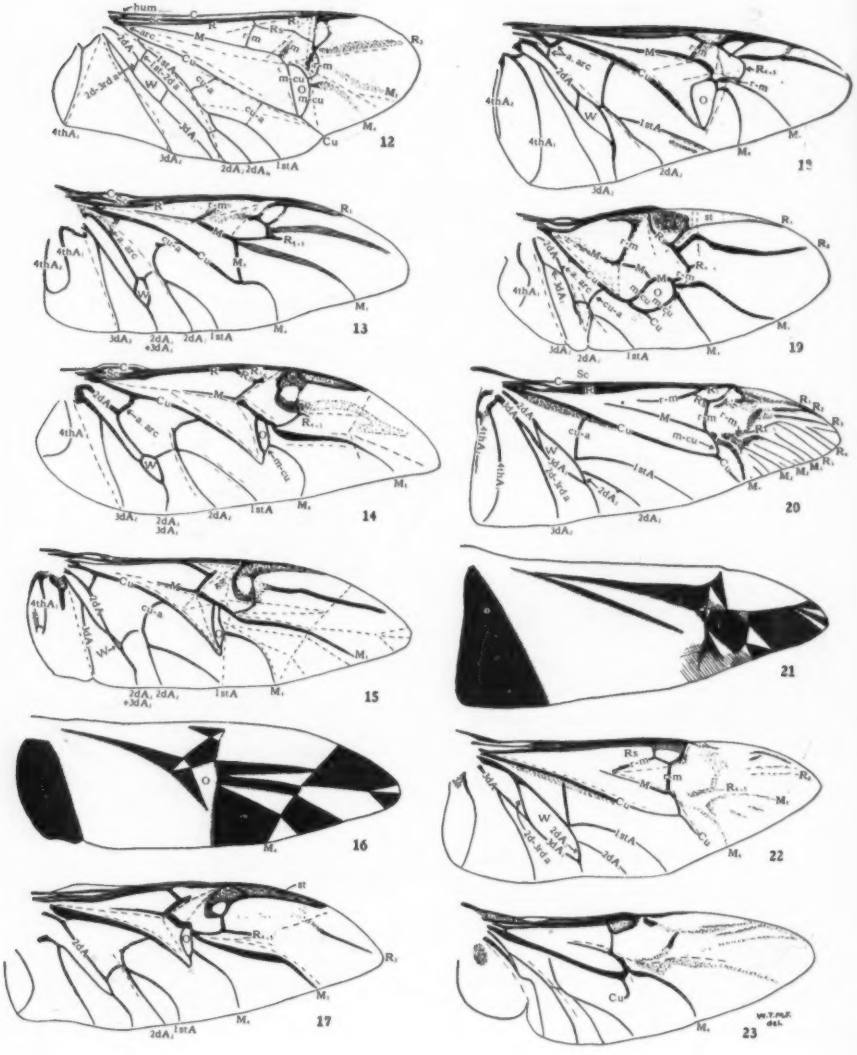

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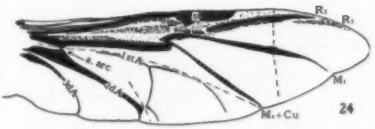

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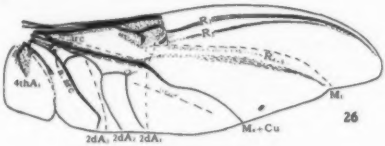

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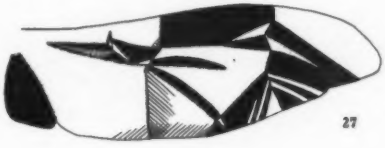
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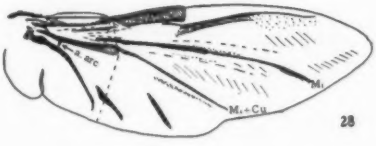

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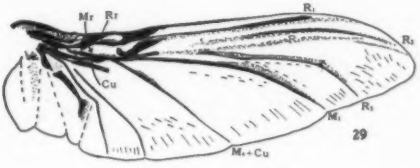

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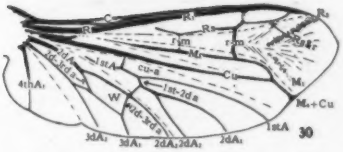

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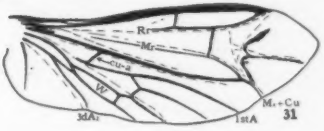

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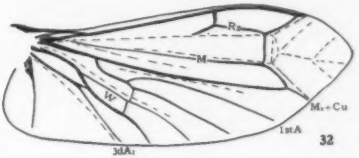

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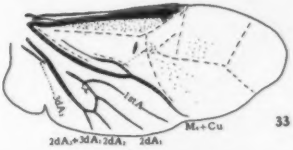

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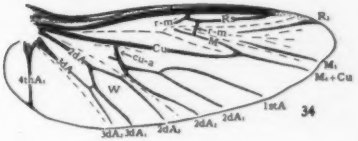

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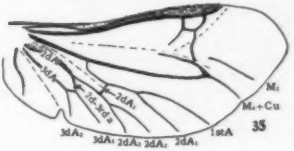

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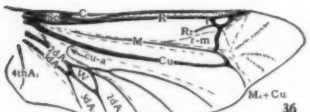

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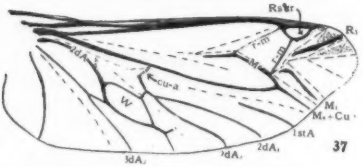

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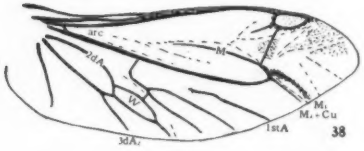

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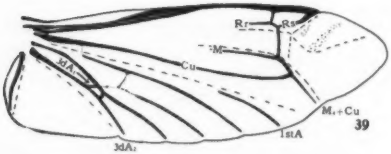

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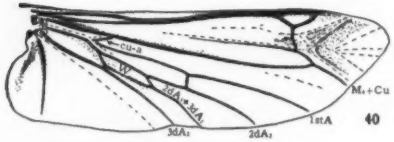

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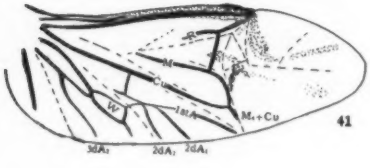

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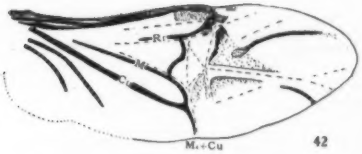

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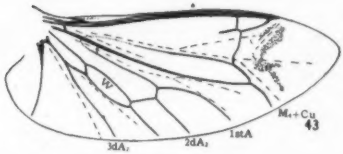

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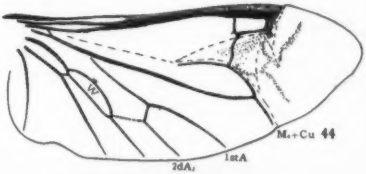

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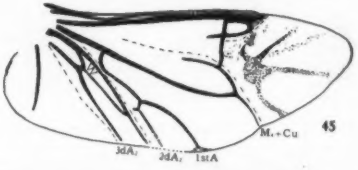

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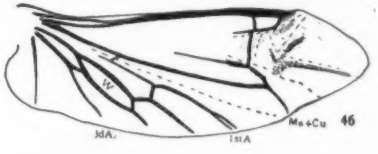

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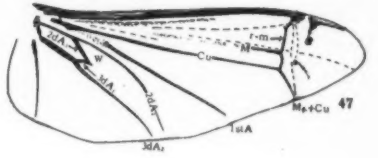

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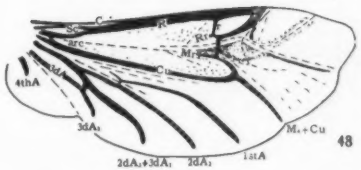

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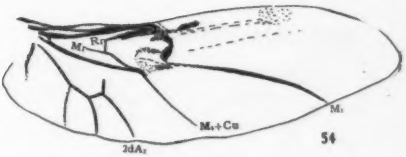

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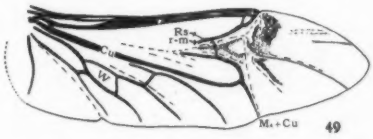

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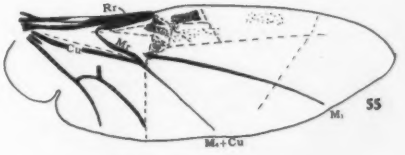

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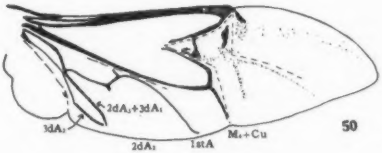

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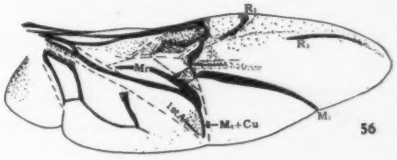

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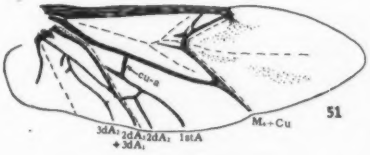

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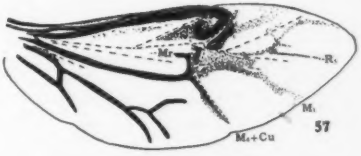

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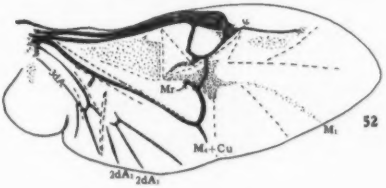

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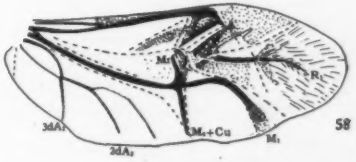

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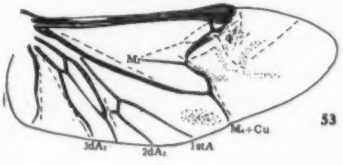

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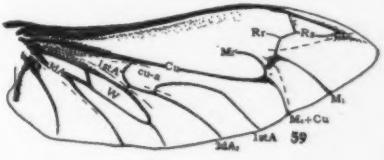

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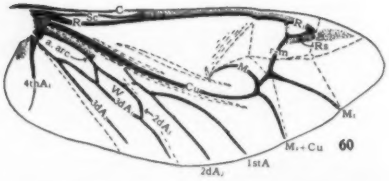

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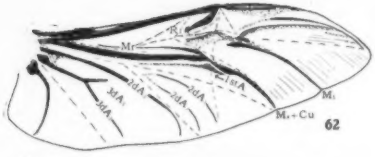

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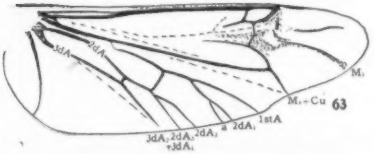

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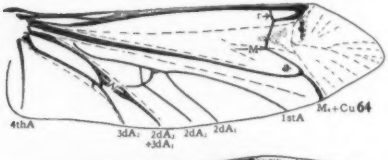

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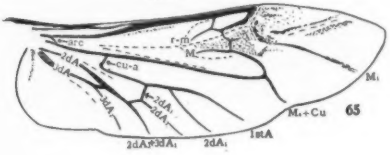

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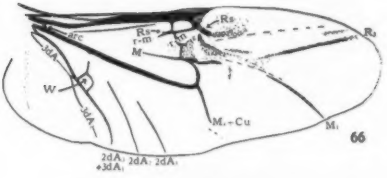

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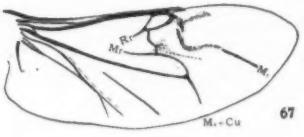

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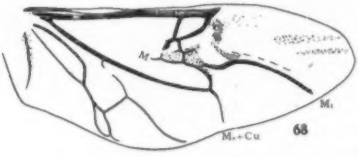

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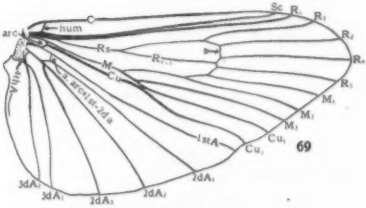

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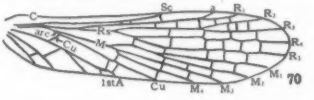

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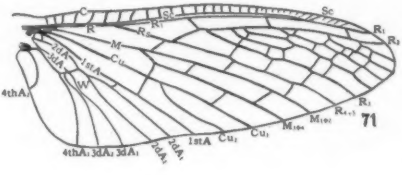

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STUDIES OF THE SPECIES IN THE GENUS CICADELLA LATREILLE (HOMOPTERA) OF NORTH AMERICA, NORTH OF MEXICO.

CHRIS E. OLSEN,
West Nyack, N. Y.

In working over the species in the genus *Cicadella*, which from time to time had gathered in the writer's collection and in collections loaned for study, it was found impossible, from the present literature, to determine and properly place all the forms at hand. Some of these closely related and undescribed forms obviously caused considerable confusion at times and it became evident that a review with further study was quite necessary.

In reviewing this genus the author was confronted by several intricate questions. These questions were communicated to and discussed with other scientists interested in this particular genus. In some of these communications the main points of the author were sustained and a good deal of encouragement was given, while in one or two cases it was pointed out that his views were probably misguided. In such cases of doubt these views were dropped for possible further consideration and study.

Liberal use has been made of "sub-species" in place of "variety"; all forms which show a more or less constant distinction from the typical species, and which it would not, by structural characters, be safe to call species, although in some cases they may be such, are placed as sub-species. All others, more or less varying in color combinations and designs from the typical form, have been given a varietal name where such was deemed advisable for the purpose of identification. In this paper little use is being made of external genital characters for the reason that where the differential characters were mostly wanted the genital differences were too small or too variable to depend on, and preference was given to other structural characters, color designs, and patterns.

The "Reivew of the *Tettigonidæ*" by Ball, 1901, has been taken as basis for this study. This valuable work, which was published twenty years ago, is today still indispensable for the

study of the sub-family *Cicadellinæ*, but since its date of publication a number of changes have been made and some additions have been found of which no records have been made; these changes and additions have all been included in this paper.

Van Duzee, 1916 and 1917, has been followed in the higher names, viz.: Family *Cicadellidæ*, sub-family *Cicadellinæ*, tribe *Cicadellini*, and genus *Cicadella*, as neither literature nor time was available for the checking-up of this.

This genus can be recognized by the two ocelli placed on the posterior half of disk of vertex, about equal distance between eyes and center, portion of the front encroaching upon the dorsal part of vertex, the ledges over the antennal sockets are not prominent and the anterior tibia are not sulcate. Distant, 1908, mentions, in separating it from *Kolla*, that "the lateral margin of the vertex in line with the inner margins of eyes." This is rather misleading, and there is no doubt that what he meant was that the lateral margins were not in line with the outside of the eyes, as they are in *Kolla*.

A number of suggestions have been made; the very first one is to consider *Cicadella viridis* Linnæus as a possible accidental introduction which did not become established on this continent.

In the study of *hieroglyphica*, the writer "struck a snag" in trying to recognize the species from the short and incomplete description by Say. On this particular point the author sought advice from other interested friends.

The answers received were varied, both concurring and contrary to a suggestion of the author. But, as it is exceedingly difficult to prove or disprove the questions that arose, it is better left as it is for the present. It is rather unfortunate that Say's type is not in existence; if it were, there would never have been the slightest doubt, but, as it is, his short description will answer for another species in this genus as well.

Cicadella confluens Uhler has been given specific rank, for the reason given in the article, and the figure will assist in explaining doubtful points. Consequently, Ball's variety *uhleri* has been shifted to be a variety of *confluens*.

Tettigonia compta Fowler, 1900, has been revived as a subspecies, a rank to which it seems surely entitled. It appears to have a different form of habitation, seeking the higher and more arid regions of Mexico. This, together with its great difference of appearance will warrant the designation of sub-species for it.

Kolla similis Walker, 1851, has been included in this genus as it seems to compare better with the type *Cicadella viridis* Linnæus than it does with the type *Kolla insignis* Distant, although I have never seen specimens of the latter type. Taking this species out of *Kolla* may possibly improve that genus, the characters of which at their best are none too good for our known, North-American species.

Cicadella circellata Baker, 1898. It is quite possible that Signoret's *atropunctata* is the same as this; further study is therefore warranted, and particularly of material from Brazil.

Through the courtesy of Mr. Edmund Gibson the writer has had the privilege of studying a collection of specimens in this genus from the United States National Museum. Dr. F. E. Lutz kindly gave permission to examine the material in the collection of The American Museum of Natural History, and Mr. H. G. Barber turned over his very valuable collection to my disposal. Mr. E. P. Van Duzee, Dr. E. D. Ball, and others have kindly assisted with desirable specimens and were kind enough to answer correspondence on this subject. To these gentlemen I am very grateful for their unfailing assistance and to them I wish here to express my sincere appreciation. These collections, together with my own, accumulated material, have made this paper possible.

Cicadella viridis Linnaeus, 1758

This species has been included in our faunal list on the strength of a single record by Provancher, 1889. The specimen was seen in Provancher's collection at Quebec, Canada, and examined by Van Duzee, 1912. Its identity cannot be questioned. This record is rather unique for such a widely distributed species of the Old World. It appears in most of the European lists as a common species abundantly collected; it is reported from the British Islands (Edwards 1888), across the Danish peninsular (Jensen-Haarup 1915–1920), through Russia (Oshanin 1907), to Japan (Onuki 1901); in Europe as far south as Italy (Ferrari 1895). It occurs in damp, grassy locations along edges of swamps and meadows.

Had this species once gained foothold and become established here, there is every good reason to believe that it, like so many other Hemiptera, would find but little difficulty in maintaining itself, if not actually spreading. At least we might

expect to corroborate this old record of Provancher, 1889. Although this record is annotated by "Peu commune, Cap Rouge," it is apparently without a definite date, but must have been collected previous to the appearance of the publication, which was issued about August, 1889, thirty-three years ago.

Until further collecting of this species on our continent occurs, it may be well to suppose that Provancher's specimen was an introduced, stray individual, and that the species so far has not become established here, which explains its absence in all other collections and local lists. Taxonomically it would be most desirable to have this species with us as it represents type of family, subfamily, tribe and genus, but economically we are better off without it. It may be well to suggest to collectors in the northern section of our territory, and especially in Eastern Canada, to be on the look-out for the possible occurrence of this species.

Cicadella marathonensis, Olsen, 1918.

Recently described and figured by the author, in the Bulletin of The American Museum of Natural History, from a female specimen collected by Dr. F. E. Lutz, at Marathon, Texas. It is regrettable that this should be the only specimen known, but it is so distinct from all our other known *Cicadellidæ* that it cannot be confused with any other species.

It has been suggested by one of our eminent cicadelists that this species may belong in the genus *Kolla* and perhaps be one of the species described there. This point has been carefully considered; although there is very little difference between the genera *Cicadella* and *Kolla* yet *marathonensis* fails to compare with the latter. The vertex is more obtuse, the area between the eyes and ocelli is slightly shallow (not foveate as in *Kolla*), and the sides of the pronotum are entirely different from that of *Kolla*, more nearly like those of *Cicadella*.

Cicadella multilineata Fowler, 1900.

This very large species was described by Fowler from Pinas Altos in Chihuahua, Mexico, and it seems that it has not been reported on since. It is quite distinct both in size and color from all our other known North American species.

Vertex well produced, markings of vertex, pronotum, scutellum and veins of elytra black in strong contrast to the yellowish-gray

ground color, with apex of vertex, anterior part of pronotum, cell between the two claval veins and subcostal cell strongly tinged with bright yellow. Size: Length 10.1 to 10.5 mm., width 2.7 to 2.9 mm.

Twelve specimens were collected by Mr. H. G. Barber at Huachuca Mountains, Arizona, July 12th to August 3rd, 1905, which agree admirably well with Fowler's description and figure except as to the color of the underside. They fail to have the bright red venter and legs described for the species, but have a pale, orange-yellow color with indications of the varigated black and testaceous rather weakly shown.

Cicadella hieroglyphica Say, 1831.

This species was described by Say from specimens collected in Arkansas. Its color and markings are subject to variation but Say mentions only one color-form and neglects altogether the details of the markings which are so important distinguishing characters at the present time. He apparently made an error or else he did not describe the commonest form when he mentions in his description "hemelytra obsoletely spotted, nervures being pale." The writer has not seen any example among the great number examined which could truly be said to have "nervures pale," except in some forms where it was evident that the pigmentation in general had not developed, or in a few examples in which the nervures were pale near the base of the elytra and for a very short distance beyond. It is not probable that Say should have selected such a specimen or specimens to describe; at least this part is a serious discrepancy in his description as throughout the whole series of *hieroglyphica* and its allied forms (except one extreme subspecies, which may, when enough collecting has been done, be considered a good species), the veins appear dark. Is it possible that Say should have had a *gothica* before him? This would be an exceedingly hard question to settle as there are no types in existence. The description in general can be applied to both species except for the "pale nervures" which would fit *gothica* much better than *hieroglyphica*. However, taking all in all and arguing for and against, it is not advisable at this time to propose any change in the taxonomy, if indeed there is to be any, but, at the same time, it is well for those that try to identify *hieroglyphica* by Say's original description to bear in mind that they have dark veins in general.

Several new forms have been recognized as additional subspecies and varieties of this species; they could not well be identified with *hieroglyphica* or any of its described varieties. It was, therefore, obvious that the describing and naming of these forms would materially lessen the difficulty in identifying both *hieroglyphica* and *confluens*. In most cases and as far as this study has revealed, these new forms are more or less confined to certain geographical areas.

Typical form: Vertex well produced, obtusely conical, about a right angle; length of head, .8–.9 mm.; width, including eyes, 1.7 mm., anterior lateral margins bulging from just before the eyes, taking up with the obtuse apex, posterior margins rather evenly and strongly arched, disk evenly and gently convex, a very slight depression between the eyes and ocelli, sculpturing not very strong, general appearance rather smooth. The general color varies considerably from yellowish-gray to greenish, and from a brick-red to a grayish-green or brown with indistinct spots and blotches on head and pronotum, with the characteristic black markings surrounding an imaginary light T and usually with streaks, more or less conspicuous, and dark veins on the elytra. Males and females of about the same color.

Say, in his description of this species, mentions only one color form, i. e., "dull rufous"; this must then be considered the typical color. It is found very commonly in this color, from which it varies into several other colors as mentioned above.

The "slaty form" mentioned by Dr. Ball, 1901, should, without doubt be referred to the variety *dolobrata* rather than to *hieroglyphica*, (see variety *dolobrata*). This color transition is more evident in the females than in the males of these two forms.

In Van Duzee's Catalogue, 1917, the distribution for this species and the there mentioned three varieties is given in common. It seems obvious and quite important that the distribution should be considered apart for each of these forms, at least in this case. Dr. Ball, 1901, arranged them in two groups and gave the distribution of each group, which was more nearly correct. These two groups will not always be found in the same territory; at least one of the groups has quite a distinct distribution. There are several other closely related, yet undescribed forms (which will be treated in the pages to follow), that have been the cause of a good deal of confusion and it is obvious that local distribution must be considered for

each one of these forms even though in some instances repetition will occur.

The range of this species, typical form, extends from the Rockies about Colorado, east throughout Nebraska and Iowa to Illinois, south-west to New Mexico and Arizona. In the East it is represented by a single capture in Tennessee, De Long 1906, and another single example in the writer's collection from La Grange, Georgia, 17, VIII, 1918, taken by Dr. A. H. Sturtevant. A quite northern record is Wisconsin, which is probably correctly identified by Saunders and De Long, 1917.

Cicadella hieroglyphica var. **dolobrata** Ball, 1901.

Shape and characters similar to that of typical *hieroglyphica* but color darker, especially in the males, which range from all black with but few light markings, to black specimens irrorate with white on vertex and pronotum.

The characteristic markings of the species are usually obsolete in the males, but not so obscure in the females and sometimes rather well defined. Their color is slate to nearly black; I have never seen a female that would answer entirely to the color description of this variety.

Following is the result of the study of two collections: First lot: Langdon, Mo. VII, 14, —VIII, 28, H. G. Barber. Seventeen specimens, nine males, (typical *dolobrata*), eight females, rather slate gray in general appearance, with a good deal of light pattern in strong contrast to the markings on the vertex and anterior part of the pronotum. They would very well pass for Ball's "slaty form" but are undoubtedly the females of the above mentioned males. The lot is fairly constant and collected in a space of about six weeks. Second lot: From "C. Mo. 96." (abbreviation for Central Missouri 1896?), U. S. National Museum Collection. Ten specimens pasted on a card, seven of which are typical *dolobrata* males, the remaining three were females with vertex and pronotum as in the former lot, but a shade darker on the elytra. These are almost indisputably males and females of the same brood.

The distribution of this variety follows that of the typical *hieroglyphica* except that it is not reported from as many places. Dr. Ball, 1901, gives the same general distribution for both, additional distributions are Olsen, 1918, Boulder, Colorado; De Long, 1916, one specimen from Colliersville, Tennessee.

There is no doubt that this variety will be found wherever the typical form occurs, if thorough collecting is done.

Cicadella hieroglyphica sub-species **lutzi** n. sub-sp.

Male: Vertex shorter and wider in proportion than in either *hieroglyphica* or the variety *dolobrata*, eyes more prominent, two longitudinal, slightly elevated ridges passing over the ocelli, leaving the central disk and the area between the ocelli and eyes slightly but distinctly concave. The whole vertex has otherwise a rather flat appearance. Pronotum rather short, and only slightly convex, lateral margins of the elytra, from dorsal aspect, tapering gradually to an acute point.

Color. A shining black spot on the apex of vertex and face, the reflexed portion of the face is finely lineated with brown, curved lines, lateral edge of vertex just behind the reflexed portion of face with a strong, short, black line almost touching the eyes. Front yellowish-white, mottled with black, but little broken up; this mottling is extended so that it connects with the apical spot at four places, a strong, median light stripe running from the black spot at the apex to the clypeus, sometimes interrupted by the black mottling crossing it. Genæ pure white, immaculate. Loræ bright yellow, fuscous along the clypean suture. Clypeus cream yellow with a dark, narrow median line. Pectus black with a broad white spot just below the eyes followed by a smaller one. Vertex with the characteristic *hieroglyphica* "T," but differing principally from the typical *hieroglyphica* as follows: A strong black line following around the base of the "T" up along both sides of the stem, following along under the divergent and recurved parts of the "T," going back obliquely across the ocelli, striking against the eyes, a lateral branch shooting forward between the ocelli and eyes, terminating before it reaches the margin in a somewhat angulate spot; the light stem of the "T" passes uninterruptedly through to the apical spot.

The suture between the reflexed portion of the face and vertex marked with a delicate, black line, pronotum dark with an anterior light band irregularly marked with black and dark brown, markings more pronounced, and of a vermiculate character on the anterior band. Scutellum with two black vittæ running from basal margin slightly inside and parallel to the lateral margins until it strikes the dark, impressed suture, directly backwards striking the lateral margins before the tip. Elytra bluish-black, the costal margin and margins of claval suture bright bluish-gray, sometimes with green mottling, nervures dark, cells irregularly sparsely spotted or mottled with gray.

Females unknown.

This sub-species can be separated from typcial *hieroglyphica* and var. *dolobrata* by its shorter, broader and flatter vertex, smaller size and more pointed posterior. Its general dark-

bluish and somewhat shining color will readily separate it from *hieroglyphica* while the light markings of the vertex will serve to distinguish it from *dolobrata*.

Described from eighteen males, specimens all from Arizona. Five males from "Phoenix, Arizona, R. Kunze Collection" American Museum of Nat. Hist. collection; seven males from "Phoenix, Arizona, R. Kunze Collection"; and one male from "Phoenix, Arizona, 6-1-02," H. G. Barber Collection. Two males from "Arizona C. U. Lot. Cornell U .Lot 411 and 414," one male from "Arizona U. Lot P. R. Uhler Collection," collection of United States National Museum. In time, it may prove to be a perfectly good species. This can better be ascertained when the female becomes known. At present the rank of sub-species will serve every purpose. Male holo-type and three male para-types in The American Museum of Nat. Hist.; four male para-types in Mr. H. G. Barber's collection; four male para-types in U. S. Nat. Mus. Coll.; six male para-types in author's collection.

Cicadella hieroglyphica sub-species **barberi** n. sub-sp.

Small, slender, pale yellowish-green, scarcely marked. Vertex, anterior pronotum, scutellum, costal margins of the elytra and all beneath from a pale straw-yellow to a slight greenish-yellow. Vertex with apical black spot, disk very lightly marked with fuscous, pattern scarcely discernible, in some specimens entirely obliterated, leaving the vertex clear yellow with only the eyes, ocelli and apical spot dark. Pronotum without maculation, posterior disk yellowish-green. Scutellum with faint traces of maculations. Elytra yellowish-green. Face and all beneath pale straw color, immaculate or slightly marked. Veins usually pale in the females.

Four females, from "Phoenix, Arizona," American Mus. of Nat. Hist. Four females, "Phoenix, Arizona, May 25, to June 8, 1902," H. G. Barber Collection. One female "S. Col." One female, "Pecos, New Mexico, August 11, Ckll.," and one female, "Santa Fe, New Mexico, Ckll.," United States Nat. Mus.

Seven males from "Glen, Sioux Co., Neb.," H. G. Barber Collection and one male, "Col. Aug. Uhler," U. S. Nat. Mus. Collection, may possibly be referred to this sub-species; they have a trifle more markings on the vertex than the females as above described and also the veins of their elytra are set off with a darker color.

Female holo-type and two female para-types in The American Museum of Natural History Collection. Male allo-type, four male para-types and two female para-types in H. G. Barber's collection. Three female para-types in U. S. Nat. Mus. Coll. Three female and three male para-types in author's collection.

Cicadella hieroglyphica var. **inscripta** n. var.

Shape and size similar to *hieroglyphica*. Face yellow, mottled with brownish. Vertex bright yellow, the disk washed with green, usual markings shining black, apical spot prominent. Pronotum dark bluish-green on disk, anterior margin more or less bright yellow, with a series of prominent black inscriptions across the entire width, which is vanishing in some specimens. Scutellum yellow with usual black margins. Elytra bright bluish-green with the margin of the claval suture yellowish-green, and the costal margins yellow to yellowish-green. Face mottled with testaceous. Venter and all beneath pale yellow, except the claws, which are dark, and a few fuscous spots on the sternum of some of the specimens.

Five females, three labeled "Arizona (Col. Baker)," one "Pecos ,New Mexico, Aug. 26 Ckll., *Verbesina exauriculata*," (Probably food plant), one "Colorado Springs, Colo., July 21, 77." All from the U. S. Nat. Mus., Washington, D. C.

Female holo-type and three female para-types in U. S. Nat. Mus. one female para-type in author's collection.

Cicadella confluens Uhler, 1862.

When Uhler described this species he placed it in the genus *Proconia* and compared it with *Proconia costalis*, now known as *Oncometopia lateralis* Fabricius. From this it is evident that the insect he described appeared to him rather closer related to *lateralis* than to any of the *Tettigonia* species. It is not easy to say why he did this for his species lacks characters to admit it into this group, perhaps its appearance was rather coarse for *Tettigonia*.

Ball, 1901, reduced Uhler's *confluens* to a variety of *hieroglyphica* and described two other varieties, *dolobrata* and *uhleri*. After studying a considerable number of specimens I have come to the conclusion that *confluens* should be considered as a distinct species with *uhleri* as a variety of it. These always possess the broadening and shortening of the vertex which Dr. Ball, 1901, refers to in the introduction of his paper. Besides

this, the front or face is considerably less convex and usually very pale with much less marking than is found in ***hieroglyphica*** and its varieties. Comparing it with ***hieroglyphica*** both in width and length, its head is broader and shorter in comparison to its total length; the lateral margins of vertex are straighter; vertex not quite so convex; elytra longer, mostly with a spotted pattern seldom displaying any stripes; general color dark brownish to bluish-black; markings on vertex quite different, the longitudinal bar of the T and the black margins bordering it are proportionately longer and thinner, appearing more drawn out and crowded together; the apical black spot is usually joined by the other black markings, sometimes barely separated; face is pale, sometimes slightly mottled; front broader, flatter, and not quite so strongly inflated.

This species is undoubtedly confined to the extreme western states, specimens are determined from British Columbia, Washington, Idaho, and California.

Certain forms of *hieroglyphica*, especially from Colorado, (perhaps a new variety) very much resemble this species and have probably been the cause of confusion; they can, however, always be separated from it by the front being darker, more mottled, narrowed and more inflated or convex, and their shorter elytra and they do not have the slender black and light lines on the disk of the vertex. Some of these specimens in the National Museum collection where labeled with a Uhler ms. name.

Cicadella confluens var. **uhleri** Ball, 1901.

This variety compares well with Uhler's *confluens* except in color, which is a grayish-green with bluish, greenish or brownish mottling, much lighter than typical *confluens*. Vertex, face, scutellum and costal margins of elytra usually brighter and more yellowish; black markings of vertex and scutellum are more delicate and fainter, sometimes vanishing; it also has longer elytra.

Occurring practically with *confluens*, perhaps ranging more eastward toward the Rocky Mountains. Specimens at hand from Washington, California, Nevada and Colorado. These localities conform with Dr. Ball's (1901) statement of distribution which names the states in the Rocky Mountain region except Montana and follows westward to the coast. Tucker

(1907) confirms the Colorado locality, whereas Gibson and Cogan (1915), if their determination is correct, extend the distribution considerably eastward, giving the western half of the state of Missouri.

Cicadella gothica Signoret, 1855.

This widely distributed species, occurring practically over the entire continent, extends its range considerably northward over a wider stretch than any other member of the genus. It is common in all the north-eastern states extending into Canada. Provancher, 1889, lists it as *Diedrocephala hieroglyphica* Say common at Cape Rouge, Ont. Mr. E. P. Van Duzee, 1914, reports it as abundant throughout the year at San Diego County, California. In the south-east it seems to cease at Tennessee, De Long, 1916; South Carolina, Metcalf, 1915; North Carolina, Olsen, 1918.

Specimens at hand from Arizona vary slightly in size and markings from those of elsewhere: (a) about the same size but all markings on vertex obliterated or nearly so, elytra unicolorous with veins faintly discernible, pale; (b) ranging considerably smaller in size, markings on vertex present and elytra of a deeper color with veins pale.

It is readily separated from the *hieroglyphica* group by its designs of the vertex. The elytra of this species has the nervures pale. It does not exhibit as great variation as *hieroglyphica.*

Cicadella circellata Baker, 1898.

It seems somewhat doubtful whether this name is valid or not. There is a good reason to believe that *atropunctata* Signoret is the same thing; his description fits tolerably well, although based on a specimen collected in Brazil, but the illustration is indeed very misleading and poor, as are many of the illustrations in the same work. However, this will need further study and especially of material from the south. Meantime, it may well be carried along as above.

Lawson, 1920, is evidently of the same opinion since he in his recent paper on "The Cicadellidæ of Kansas" calls this species *atropunctata* Signoret.

Cicadella occatoria Say.

Described by Say from Indiana. Fowler, 1900, gives a very fine color figure of this insect. It is variable to some extent in the amount of green and yellow color, also the markings show a gradation of various tints from reddish-brown to brown and black.

Dr. Ball, 1901, lists *Tettigonia compta* Fowler as a straight synonym of this. I would hesitate that our common form in the south-eastern states should be identified with *Tettigonia compta* because of Fowler's description and particularly his color figure which is very well executed. Therefore, I would separate this form from *occatoria* and consider it a a sub-species at least, to which, I am sure, it is entitled. Dr. Ball, 1901, records it as common in Florida, Mississippi and Texas. To this must be added Gibson and Cogan, 1905, common in eastern Missouri; De Long, 1916, specimens swept from various places in Tennessee; Metcalf, 1915, two localities in North Carolina; and Lathrop, 1917 and 1919, three localities in South Carolina. The type locality is in Indiana. Its range extends far to south of our fauna.

Cicadella occatoria sub-species **compta** Fowler.

Comparing this form with the true *occatoria* it will at once be seen to be of much redder color, but lacking the green. On the vertex the two outer of the four red vittæ are much broadened on the reflexed portion of the face, and are subdivided into two or three narrower stripes on this place; they are really a continuation of a series of ten or twelve red arches on either side of the face, which extend up to this part of the vertex and take up with the stripes running back over the pronotum and clavus. The inner pair of vittæ form a decided loop at a distance of two-thirds from the base of the head and run back over the pronotum, scutellum and clavus. The fifth or central vitta commences on the pronotum and runs back over it and the scutellum.

The red vittæ of the elytra are much broadened and leave only narrow, yellow vittæ between them. The apex of the elytra is hyaline and the characteristic "blackish tip with yellowish band" as mentioned in Say's description, is wanting.

This form seems to frequent more elevated and arid regions of Mexico, whereas typical *occatoria* is usually found along the south-eastern coast-line at comparatively low elevations.

Six specimens in the collection of Mr. H. G. Barber come from Huachuca Mountain, Arizona, July 13 to 22, 1905.

Cicadella dohrnii Sign.

I have seen only a few examples of this species from Arizona and Mexico. It was described by Signoret from Mexico, and without doubt this is the insect which later was described by Baker, (1898, p. 286) as *Tettigonia aurora* and by Fowler (1900, p. 269, Pl. XVIII, Fig. 5) as *delicata*. This has been pointed out by Dr. Ball, 1901, who gives a very comprehensive description and an excellent figure by which it can be readily determined.

Cicadella similis Walker, 1851.

In comparing this species with the description of the genus *Kolla* Distant, 1908, I find that it does not agree very well. In the first place, the vertex is obtuse, rounded anteriorly rather than subconically narrowed; in the second place, the fovea next to the eye is scarcely discernible, variable, and amounts in many cases to a shallow depression which is so often seen in the genus *Cicadella*.

The face has the lateral areas somewhat strongly striate, but this is also a character in most of the *Cicadella* species. The centrally longitudinal area is sometimes flattened, and sometimes gently rounded, the dark and light arches meeting a narrow, light, central longitudinal vitta. The outline or profile of the face is markedly different from our species of both *Cicadella* and *Kolla*, bending rather abruptly just before the clypeus and the latter itself having quite a bend, these two bends producing a wavy appearance to the lower part of the profile of the head. Considering the above characters, I suggest that this species be placed in the genus *Cicadella*, where I think its color pattern, shape and general appearance will be in greater agreement.

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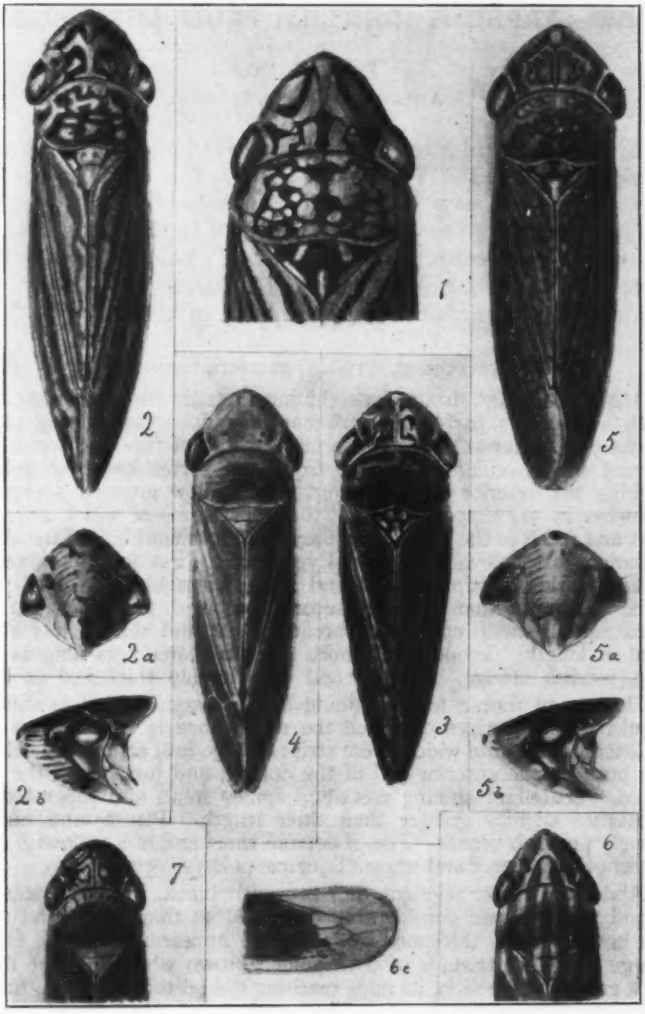
EXPLANATION OF PLATE XXXVI.

Fig. 1. Dorsal view of *Cicadella multilineata* Fowler.
Fig. 2. Dorsal view of *Cicadella hieroglyphica* Say.
Fig. 3. Dorsal view of *Cicadella hieroglyphica* subsp. *lutzi* n. subsp.
Fig. 4. Dorsal view of *Cicadella hieroglyphica* subsp. *barberi* n. subsp.
Fig. 5. Dorsal view of *Cicadella confluens* Uhler.
Fig. 6. Dorsal view of *Cicadella occatoria* Say.
Fig. 7. Dorsal view of *Cicadella similis* Walker.
a, front view of face; *b*, side view of head; *c*, apical half of elytra.



C. E. Olsen

NEW SYRPHIDÆ (DIPTERA) FROM MISSISSIPPI.

By Frank M. Hull
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Mississippi is in a region that is as yet almost wholly unexamined in regard to its dipterous fauna. The discovery of two very interesting new species of Syrphidæ from the trifling number that have thus far been collected in the state argues a rich return from collecting in the future. The writer wishes to express his appreciation to Mr. C. H. Curran, who has kindly verified his determinations, particularly of the *Microdon*.

Microdon (Omegasyrphus) **painteri,** new species.

Male: Face and front dark shining metallic bronze, of medium width and nearly parallel. Oral margin and cheeks shining black. Cheeks and posterior orbits white pilose. Pile of face and lower half of front white, on upper half of front and vertex brownish yellow. Marking the anterior third of front is a shallow grooved depression somewhat in the shape of a "Y" the upper arms of which are wide apart and reach to the eyes. Face projecting for about half of its width, beginning just below the eyes. Eyes bare. First joint of antennæ reddish, darker at tip; second and third joints black. Third joint distinctly shorter than first and second combined, pointed at tip and approximately twice as long as broad. First and third joints about equal in length; second joint short. Arista scarcely as long as last joint, reddish orange, brownish and considerably thickened at base.

Dorsum of thorax feebly shining bluish black; with five shining, purplish bronze stripes of which the middle one is very narrow and the lateral ones quite wide; these stripes merge into a similarly colored area both on the anterior end of the dorsum and just before the scutellum. Scutellum shining metallic; spines small and separated by a distance slightly greater than their length. Pleuræ and humeri strongly purplish bronze. Pile of dorsum short and of a yellowish cast, that of pleuræ longer and white. Squamæ pale yellowish.

Abdomen: First segment dull brownish black, but little shining. Second widened and considerably depressed so that the lateral margins have a much thickened and rounded appearance on the edges; a large indistinct triangle of dark golden brown which in some lights has a greenish reflection, its apex reaching the posterior margin, has its base along the anterior margin. The remainder of this segment and the rest of the abdomen light, slightly brownish red becoming a little darker on the fourth segment. Whole abdomen faintly shining; pile

or pubescence short, white, longer on the lateral margins and more noticeable on the third and fourth segments. Venter concolorous with the dorsum with the exception of the first segment which is blackish.

Femora black, shining, with very short and sparsely white pile; apex of femora and trochanters reddish. Tibiæ reddish, piceous at their outer ends, covered with short abundant white pile; first joint of hind tarsus considerably enlarged. Wings hyaline with a dark brownish cloud in the middle on the anterior half of wing, smaller clouded areas following the veins closing first and second posterior cells and about the marginal and submarginal cells. Veins brown; stigma luteous. A stub of a vein extrudes half way across the first posterior cell at its middle.

Female: Very similar to the male. All three joints of the antennæ light yellowish brown, outer half of last joint grayish or blackish. Arista entirely reddish yellow. Front noticeably wider. The ground color of thorax appears more metallic and greenish. Scutellum more purplish bronze. The second segment lacks the brown triangle and is entirely reddish.

Femora dark shining red. Tibiæ and tarsi light brownish red; pile of the former white, of the latter brownish yellow. Infuscated spots and veins of the wing smaller in extent. Ocelli bright shining red.

Length: 10 mm.

Holotype male and two paratype males taken in a cypress swamp on September 18, 1920, at Greenville, Miss., (F. M. Hull). Allotype female from College Station, Texas, September 28, 1920, (H. J. Reinhard).

Holotype and paratype in the collection of the author. Allotype in the collection of Mr. Reinhard.

It gives me pleasure to name this species in honor of Mr. R. H. Painter who has been active in the collection of the Syrphid fauna of the region.

Somula mississippiensis, new species.

Male: Antennal process extraordinarily long and prominent; the distance from base above to tip being approximately half as long as the distance from the base above to the epistoma or twice the length of the process in *Somula decora* Macquart; yellow below, entirely black above, the black extending to the eyes, its margins straight. Antennæ black; second and third joints covered with microscopic, light colored pubescence; arista yellowish red near base, blackish apically. Face below antennal process only slightly concave and a little convex on lower part; descending perpendicularly considerably below the eyes; shining pale yellow, with a black median stripe extending from the epistoma to half the length of the antennal process on its lower surface. Cheeks shining black. Front black, almost destitute of the rather long, yellow pile that sparsely covers the occiput and the posterior orbits

below. On each side of the antennal process, with their bases against the eyes, are two triangular areas with microscopic, almost white pubescence.

Thorax a faintly shining black with five, dorsal, narrow, obscure metallic golden green stripes, merging into similarly colored area both at the anterior end and just before the scutellum, which gives to the black of the thorax a greenish cast. Scutellum shining; entirely metallic greenish black. Pile of medium length, rather thick and yellowish. Humeri opaque yellow, yellow pilose. Mesopleuræ black, with an oval yellow spot, yellow pilose. Squamæ yellow.

First segment of abdomen black, feebly shining. Second, third and fourth segments black, nearly opaque, each with a pair of opaque yellow spots and a shining, metallic, brassy band on posterior margin. Dorsum of abdomen short yellow pilose throughout. The posterior band of second segment is uniform in width, does not quite reach the lateral margin but turns up along the sides and reaches the anterior margin of the segment. The metallic part of the third segment is similar except that the posterior band is much wider in the middle and narrower on the sides. On the fourth it covers practically the whole of the segment and the black is limited on the posterior side to a narrow band encircling the spots. Fifth segment wholly shining metallic. Hypopygium feebly shining brownish or reddish. The spots of the abdomen are well separated, do not reach the lateral margin and are much smaller and more transverse than those of *Somula decora*. Those of the second segment are oblong and slightly narrowed on the inner end, and not quite twice as long as wide. Those of the third segment are not pyriform but are oblong, nearly three times as long as wide, slightly concave on the anterior and convex on the posterior side. The spots of the fourth segment are similar but somewhat smaller and a little more concave. A small yellow oblique triangle has its base on the anterior margin, touching lateral margin of the second segment, and a much smaller but similar pair of spots on the third segment. Venter shining black with yellow posterior margins to the segments, those of the first and fourth being widest. Legs light brownish yellow and covered with thick yellow pile. Hind femora along the inside with a number of short black bristles like hairs.

Last three joints of all the tarsi blackened; with blackish pile. Wings dark brown before the fourth longitudinal vein, becoming yellow near the base, hyaline posteriorly.

Female: Very similar to the male. The posterior metallic band of the second segment is nearly wanting, the yellow triangles in the anterior corners of the second are smaller, those of the third segment obsolete. The hind femora lack the black bristle like hairs on the inside. The black facial stripe extends narrowly to the tip of the antennal process; in one male paratype this is also true.

Length, including the antennal process: 17 mm.

Curiously enough, the first specimen of this magnificent species, a male, was taken at Agricultural College, Mississippi, May 6, 1920, dead but in perfect condition, from a cobweb! On March 3, 1921, a fragmentary but unmistakably identical specimen was taken from a cobweb in the same locality. Subsequently three specimens, two males and one female, have been taken by Mr. R. H. Smith on flowers of *Cratægus*, on April 2, 1922, at the college.

This species will be at once distinguished from *S. decora* Macquart, by its unusually long antennal process, its black facial stripe and the shape and configuration of the abdominal spots besides minor differences.

Types in the collection of the author.

NOTES.

Among the papers being published as reports of the Barbados Antigua Expedition of the Iowa State University* there have appeared two on insects which will be of interest to Entomologists. The first is a paper by Professor Dayton Stoner, on the Scutelleroidea, pages 3 to 17, with three plates. Seventeen species are listed with careful notes on distribution and ecology, and while most of the species are common to the West Indian regions, these records give valuable data as to the local distribution. The report on the Orthoptera and Dermaptera, pages 19 to 44, by Mr. A. N. Caudell, includes detailed records for a number of interesting species, the distribution of which has been much extended, and also descriptions of four new species.

The report of the proceedings of the 4th Entomological Meeting at Pusa, February 7th to 12th, 1921, edited by Bainbridge Fletcher, Imperial Entomologist, like the preceding reports for 1918, 1919 and 1920, contains a wealth of material on the Entomological work in India. The papers on Pink Boll Worm, by E. Ballard, and the one on Winter Spraying against the Mango Hopper and also the article on the use of Bichloride of Mercury, in the Destruction of Mosquito Larvæ, by Mr. Sen, will be of particular interest to American Entomologists, the first on account of the present fight against the dispersal of the species in our cotton states—the latter two as related to control measures for leafhoppers and mosquitoes.

H. O.

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